University of Alberta

Factors Affecting the Adoption of Websites and Online Services

by

Patricia Lea Beatty

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Abstract

Many factors play a role in users' interactions and transactions online. This thesis examines the factors that affect the use of websites and online services from a technology adoption point of view. A meta-study conducted on 28 research reports found that there were 17 factors affecting the use of websites and online services: Usefulness, Trust, Ease of Use, Risk, Integrity, Benevolence, Attitude, Competence, Reputation, Predictability, Previous Actions, Ability, Social Pressures, Cognitive Enjoyment, Demographics, Innovativeness, and Other. Several empirical investigations were then performed studying the use of Privacy Enhancing Technologies (PET), HTML, Cascading Style Sheets (CCS), and hypertext links on the World Wide Web. These technologies are examined within the context of user adoption of websites and online service. In general it was found that the World Wide Web is in a very poor state of repair with most websites having errors of some type, which can negatively affects users' experiences.

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List of Abbreviations

- ANOVE: Analysis of Variance
- CIA: Central Intelligence Agency
- CSS: Cascading Style Sheet
- GDP: Gross Domestic Product
- HTML: HyperText Markup Language
- IDT: Innovation Diffusion Theory
- IP: Internet Protocol
- MM: Motivational Model
- MPCU: Model of PC Utilization
- OECD: Organization for Economic Co-operation and Development
- P3P: Platform for Privacy Preferences Project
- PET: Privacy Enhancing Technology
- PPP: Purchasing power Parity
- SCT: Social Cognitive Theory
- SEM: Structural Equation Modeling
- TAM: Technology Acceptance Model

- TPD: Theory of Planned Behavior
- TRA: Theory of Reasoned Action
- USD: United States Dollars
- UTAUT: Unified Theory of Acceptance and Use of Technology
- W3C: World Wide Web Consortium
- XHTML: Extensible HyperText Markup Language
- XML Extensible Markup Language

1 Introduction

The Internet is rapidly expanding as more businesses open up online stores, more websites are created, and more consumers go online. According to a recent survey, there are over 118 million website on the World Wide Web as of May 2007 with 12.8 million sites being new this year [1]. Several prominent online companies such as Google, Yahoo, and eBay now have multi billion dollar revenues and online revenue is climbing in many industries. United States advertising revenue up to $16.8 billion USD in 2006 from $12.5 billion USD in 2005 [2], online travel revenue at $85 billion USD in 2006 [3], and online gambling revenues predicted to be almost $17 billion USD by 2009, triple 2003 revenues [4]. The growth of business on the Internet is mirrored by the large number of users on the Internet. The CIA World Factbook states that there were over 1 billion Internet users worldwide as of 2005 [5] and an estimated 10% of the world population have made at least one online purchase [6].

1.1 Problem Overview

Online trust is becoming an important factor in e-commerce growth and general Internet use as more consumers and businesses move online. Trust is a difficult concept to define, especially when it comes to online trust. McKnight and Chervany performed a review of sixty-five trust related articles to examine trust definitions [7]. They found that the construct of trust was defined in many ways and could be very confusing to researchers. Research has defined trust as a noun, verb, personality trait, belief, social structure, and behavioral intention and some research even elects not to define it. McKnight and Chervany state that there are 2 reasons for this complexity and confusion in defining trust. The first is that each discipline examines trust within the constraints of their research, which provides a limited view of the construct as a whole. The second reason is that trust is "massive in terms of the meanings it conveys". Trust has many different meanings in different situations and these all must be incorporated into a full definition. Distrust of websites and web services is a major deterrent to Internet use and e-commerce. A recent study by Consumer Web Watch reported that 86% of Internet users have changed their online behavior while 29% have reduced their online purchases because of concerns about identity theft [8]. A Pew Internet report found that although 75% of people thought the Internet was a good place to conduct transactions, only between 22% and 55% of people actually conducted any transactions [9]. One of the main reasons cited for this discrepancy is a lack of trust online. There have been some successes in developing online trust and a good example of this is eBay[1]. As an online auction site eBay has been very successful in developing a thriving C2C commerce environment with revenues of $4.5 billion USD in 2005, up from $3.3 billion USD in 2004. eBay has developed a reputation system where both sellers and buyers can receive feedback from other users who have completed transactions with the aforementioned parties. Feedback is produced for over half of the transactions (51.7% for sellers and 60.7% for buyers) [10]. Research has found as much as an 8.1% difference in selling price between new sellers and sellers who have an established reputation [11] and sellers with good reputations were more likely to sell items than those with bad reputations [10]. eBay is a good example of the implications for developing online trust.

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[1] http://www.ebay.com/

Online trust is closely related to online technology adoption as trust is often seen as a major antecedent of use of an online system [12-15]. There is currently a large body of research in the area of online technology adoption. The research may look at different types of technology such as e-commerce [16, 17], online banking [18, 19], health care advice [20, 21], or online filing of taxes [22]. The research also may focus on a specific attribute that affects adoption of online technologies such as trust [23, 24], privacy [25, 26], or familiarity [27]. The goal of the research presented here is first to consolidate this research into a more comprehensive view of online technology adoption, with a specific interest in trust as an antecedent of use; and second to examine current website privacy practices and website correctness within this framework.

1.2 Research Question

Defining a purpose is an important first step in performing a meta-study on a body of research [28]. The purpose describes why a study is taking place and what outcomes are possible. The particular field of research that will be examined here is the area of online trust. A large selection of research exists which examines online trust and formulates various models to describe it. Many researchers have chosen to create a new model describing online trust as opposed to building off existing work, or have chosen to only examine a very small subset of online trust. This has resulted in a large body of work with no common or underlying framework to describe it. The purpose behind doing this meta-study is to examine current research in an effort to develop a more complete model of online trust.

The research question defines the focus of the meta-study. When formulating a research question, it must be broad enough to contain the topic of research but narrow enough to make the study feasible to perform [28]. The research question to be examined by this study is "What are the factors that influence a subject's decision to use an online resource and in what way do those factors interact?"

A theoretical framework allows the meta-study researcher to define various concepts contained in the research question. The theoretical framework should be able to encompass differences in interpretations by researchers while providing a boundary for the study [28]. For the purpose of this study, a definition must be developed for what is meant by an "online resource" and what it means for a subject to use that resource.

For the purpose of this study, an "online resource" is any website, and any service which that website may provide. The types of websites and services will not be restricted; anything from purely informational to e-commerce, online banking, blogging sites, and search engines will be considered. Use of an online resource for the purpose of this study will be to visit a website or to use that website's provided services. Use of an online resource is heavily dependent on the type of resource being discussed. For example, to use a search engine means to query it for some piece of data; while to use a news site simply means to read it.

1.3 Outline

The remainder of this thesis is organized as follows. Section 2 details the meta-study performed and the resulting framework to describe the use of websites and online services. Section 3 discusses privacy and presents a survey of website's adoption of P3P. In Section 4, the results of three website correctness surveys are presented and discusses. These three surveys examined websites' adherence to W3C's HTML specifications, adherence to W3C's CSS specifications, and the working order of hypertext links.

Finally, Section 5 offers discussion and conclusions drawn by the previously stated research.

2 Meta-Study

2.1 Introduction

The research examined in this chapter uses a variety of methods to collect and analyze data on the adoption of online technologies. Some research uses online surveys to collect data and structural equation modeling to analyze the data. Other research uses discussion groups to collect data and then presents quotes from the transcripts and an analysis of how often specific ideas were discussed. Of the 28 primary research reports included in this study, 14 of them used web based surveys, 8 used in person surveys, 2 used focus groups, 1 used a telephone survey, and 6 used an unspecified survey method. The analysis methods also varied widely. Of the 28 primary reports, 18 used factor analysis, 7 used structural equation modeling, 4 used regression analysis, 5 used various other types of statistical methods, and 2 qualitatively coded the data. Because of these vast differences in the exploratory methodologies, it was decided to perform a qualitative analysis of the research. There is no way to reliably combine such different research using quantitative methods.

According to Paterson et al, meta-study is a qualitative process of analyzing previous research in a particular field of study (meta-analysis) and synthesizing the findings from this analysis into a new interpretation of the field of study (meta-synthesis) [28]. Meta-study involves the analysis of theories, methods, and data from previous research in a field of study, followed by synthesis in an effort to generate new knowledge and new understanding concerning the research area involved.

Meta-study is divided into four main components; the three analytical components of meta-data-analysis, meta-method, and meta-theory, and the synthesis component meta-synthesis. Meta-data-analysis is the study of finding in research reports in a particular area of study. This component involves processing data from a wide selection of findings in order to discover similarities and differences in the accounts. Meta-method is the study of the soundness and validity of the research methods used in studies. This component involves determining how appropriate the various research methods are that are used in the research reports studied. Meta-theory is the study of the underlying theoretical structure that research is based upon. This involves analyzing the perspectives on which research design is based, the sources and assumptions of theories, as well as the greater context that theories are present within. Meta-synthesis is the process of creating a complete picture from the above analytic processes. It is the process of synthesizing all previous analysis into a new interpretation of the field of study. This study will perform a meta-data-analysis on the contents of the selected primary reports followed by a meta-synthesis that will integrate the data into a new model.

The main purpose for performing a meta-study in a particular field is to form a theory concerning a large body of research in the field. As an end product, a consolidation and new interpretation of the body of work, as opposed to a summarization, should be expected. Paterson et al give several limitations to the process of meta-study that should be remembered [28]. The first limitation is that a meta-study decontextualizes the data. The meta-study researcher must rely on how well the original researcher described the context within which the report was created. The second limitation is that the quality of the study is dependent on how well the original researcher articulated the design and findings in the primary report. This will determine how well the meta-study researcher can understand and follow the original researchers decisions.

2.1.1 Technology Adoption

As the Internet continues to expand, the question of what make a user choose to use a site or not becomes increasingly important. This is especially the case with e-commerce businesses as the success of the company depends on consumers' willingness to use the website. Many researchers have examined this problem in an effort to find a model of Internet use. Some researchers have applied well-established technology adoption models such as the Technology Acceptance Model (TAM) [29] and Innovation Diffusion Theory (IDT) [30] while others have developed their own model to explain the adoption and use of online technologies. What follows is an overview of the technology adoption models currently being applied to this area.

The Technology Acceptance Model examines the effects of perceived usefulness and perceived ease of use on the adoption of a technology by a user where perceived usefulness is how much a technology helps the user accomplish their task and perceived ease of use is how simple the technology is for the user to use [29]. TAM is often altered slightly and used to model website and online service adoption. Lee et al [31] adds into the TAM model the idea of risk to describe e-commerce adoption while Shang et al [32] adds the ideas of cognitive absorption (how "fun" the technology is) and fashion involvement (how "cool" the technology is). TAM has also been combined with trust and the Theory of Planned Behavior (TPB), which takes into account social pressures and how hard a user perceives it is to implement the behavior [22].

The Innovation Diffusion Theory looks as social, economic, and technical factors that effect the adoption of a technology into society [30]. Specifically, IDT examines four factors that influence the diffusion of an innovation in society; the characteristics of the innovation, the communication channels through which information about the innovation could spread, the time it takes specific groups of adopters to adopt the innovation, the social system within which the innovation is being adopted. IDT considers the following characteristics of an innovation when examining technology adoption:

- Relative Advantage: The advantage an innovation has over its predecessors.
- Compatibility: How compatible the innovation is with users' existing values and experiences.
- Complexity: How difficult the innovation is to learn to use.
- Trialability: How easily the user can try out and experiment with the innovation.
- Observability: How visible the results and benefits of the innovation are to users.

Innovation Diffusion Theory is not as prevalent in literature relating to online technology adoption as TAM is, however some studies have used it as a basis for their adoption models. Both Slyke et al [33] and Sarrina Li et al [34] use IDT as a foundation for developing the models used in their research. Slyke et al takes the approach of examining various IDT characteristics of innovations such as relative advantage, complexity, and compatibility and adding in ideas such as trust and prior web experience. Sarrina Li et al however, take a different approach. Instead they examine the communication channels used to spread knowledge of the innovation, the time it takes various individuals to adopt an innovation, and the social setting within which the innovation is present. Several studies have combined IDT with TAM [35, 36] by using compatibility with perceived usefulness and perceived ease of use in the context of e-commerce.

Many researchers in the area of Internet use and adoption have created independent models to describe a range of situations. Most of these models describe a specific online application such as general e-commerce situations [16, 27, 36-41], the use of health sites [20, 21], use of online banking [18, 19], accepting online advice [42], or even using online hotel websites [43]. Although some studies examine the general case of Internet use and users' willingness to use online services and websites [15, 44-46] they often only examine a specific part of the general problem. For example, [44] looks only at information quality, system quality, perceived effectiveness, and social influence and the effect these have on a users' satisfaction with a website. In [15], the effects of credibility, ease of use, and risk on trust are examined. Fogg et al [45] gives many very specific factors such as design look, company motive, tone of writing, and readability to describe how website credibility is achieved, while [46] describes only the transfer of trust between a trusted website and an unknown website.

Venkatesh et al [47] performed an empirical study of eight different technology adoption models and used this to formulate a Unified Theory of Acceptance and Use of Technology (UTAUT). The eight models in the study were the Theory of Reasoned Action (TRA) (review of use by [48]), the Technology Acceptance Model (TAM) [29], the Motivational Model (MM) [49], the Theory of Planned Behavior (TPB) (review of use by [50]), Combined TAM and TPB [51], the Model of PC Utilization (MPCU) [52], the Innovation Diffusion Theory (IDT) [30], and the Social Cognitive Theory (SCT) [53].

The unified model presented included the following factors as contributors to users' behavior or intended behavior:

- Performance Expectancy: how the user expects the system will help him or her with job performance
- Effort Expectancy: how easy the user believes the system is to use
- Social Influence: how much the user believes that others think he or she should use the system
- Facilitating Conditions: the user's belief that an organization or technical infrastructure supports use of the system
- Gender: the user's gender
- Age: the user's age
- Experience: the user's experience with the system
- Voluntariness of Use: whether or not the user is required to use the system

Venkatesh et al [47] found in an empirical study that UTAUT explained 70% of the variance in usage intention. However, UTAUT is very general and lacks some of the factors that are important when examining Internet use such as trust [7, 14, 46] and risk [15, 31].

2.1.2 Online Trust

Trust can be a difficult term to define as it can mean different things in different contexts and to different people [7]. The Compact Oxford English Dictionary[2] defines trust as:

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[2] http://www.askoxford.com/

"Firm belief in the reliability, truth, ability, or strength of someone or something; acceptance of the truth of a statement without evidence or investigation"

This definition becomes insufficient however, when trying to define and understand online trust, as it does not why or how trust is achieved.

McKnight et al [7] performed a comprehensive review of the meaning of trust in various disciplines such as psychology, economics, and sociology. They found that trust could be categorized in two ways, first by characteristics of the trustee, and second by conceptual type. McKnight et al found that 92% of all trust definitions of trustee characteristics could be described by the four categories of benevolence, integrity, competence, and predictability where benevolence means caring and acting in the best interests of the trustor, integrity means being truthful and fulfilling promises, competence means having the ability to do what is necessary, and predictability means having actions that can be forecasted by the trustor. When categorizing trust by conceptual type, the categories were dispositional which is having a disposition to trust others, institutional which is the trust in the situation or structures, and interpersonal which is trust in specific other parties and is comprised of trusting beliefs, trusting intentions, and trusting behavior.

Wang and Emurian [54] developed an overview of online trust based on the work done in the disciplines of philosophy, psychology, management, and marketing. They found that there are four main characteristics of trust:

- There must be two specific parties involved, the trustee or party to be trusted and the trustor or trusting party.
- Trust involves the trustor being vulnerable.
- Trust leads to risk-taking actions.

- Trust is subjective and will differ based on the parties involved.

Corritore et al [14] gives a definition of online trust as:

> "an attitude of confident expectation in an online situation of risk that
> one's vulnerabilities will not be exploited"

They go on to develop a model of online trust where several factors directly or indirectly influence trust in an online situation. Various external factors such as the situation, characteristics of the trust (propensity to trust, prior experience), and characteristics of the trustee (website layout, content accuracy, 3rd party verification) as well as perceived factors such as credibility, ease of use, and risk have an effect on trust in the Corritore et al model. Gefen [37] describes online consumer trust as being comprised of three dimensions; the trustor's belief in the ability, integrity, and benevolence or the trustee. This is similar to McKnight et al [7] who found that competence, integrity, and benevolence were important characteristics of the trustee when building trust.

2.1.3 Structural Equation Modeling

Structural Equation Modeling (SEM) is a statistical method for testing hypothesized relationships between observed and latent variables. This process is described in detail in [55]. The first step is to specify the model that will be tested. This model is a statement about the relationships between the variables to be analyzed. It consists of parameters that indicate the nature of a relationship between two variables. These parameters can be fixed (usually as zero) and are not estimated form the data, or free and are estimated form the data. The relationships in the model can be one of three types, association, direct effect, and indirect effect. An association between two variables in the model is non-directional, a direct effect is a directional relationship between a dependent and independent variable, and an indirect effect is the effect on a dependent variable by an independent variable through one or more other variables.

The next step in SEM is to estimate the free parameters from the observed data. Iterative methods are often used. These methods attempt to find values for the parameters that will give a covariance matrix similar to the observed one. After each iteration, the implied covariance matrix calculated from the free parameters is compared to the observed covariance matrix. The result is called a residual matrix. The iterations continue until the values in the residual matrix cannot be minimized any further. A single number called the "value of the fitting function" is produced once a solution is achieved. This number approaches zero, as the implied matrix and observed matrix more closely resemble each other.

The extent to which a model fits the observed data is determined by the extent to which the implied covariance matrix resembles the observed covariance matrix. This is a statistical problem that takes into account the data, the model, and the estimation method. The χ^2 goodness-of-fit test is the most common fit index and is derived directly from the value of the fitting function. A smaller value for this index indicates a better fit as this would imply a smaller value of the fitting function. Several other fit indices have been developed (such as the normal fit index and the nonnormal fit index) which are collectively called adjunct fit indices. These values are calculated by comparing the fit of a null or independent model (where all parameters are set to zero) to the fit of the model being tested. These indices indicate the improvement the specified model has over a null model.

SEM is used frequently to test hypotheses in empirical research in trust and technology adoption literature. Dinev and Hart [56] uses SEM to test a model of how privacy concerns effect Internet use while Chellappa and Sin [57] use SEM to examine the relationship between users' desires for personalization services and their privacy concerns. Chen et al [35] uses the SEM techniques to test a model describing the adoption and use of online stores by consumers. Multiple regression, analysis of variance (ANOVE), and factor analysis are all considered to be themselves structural equation models [55]. These types of statistical analysis can also be frequently found in trust and technology adoption literature [19, 33, 34, 38, 43, 58, 59].

2.2 Methodology

The quality of the final research is dependent on the quality of the data used within it. In the case of a meta-study, the data used are research reports. Ensuring transparency in all aspects of the retrieval and assessment of primary research reports is key to the validity of the final meta-study.

2.2.1 Finding Primary Research

There are many sources that can be used to find applicable research reports. These may include online databases, reference lists in research reports, abstracting services, citation indexes, and professional and journal networks that can provide unpublished reports. Different sources may have different criteria for what is included or excluded so it is important to understand each retrieval mechanism. Paterson et al [28] suggests using multiple search strategies to find the necessary reports for the meta-study. With regard to the volume of reports used in the study, Paterson *et al.* [28] suggest a minimum of "a dozen" but not more than "100 reports", although this is clearly very dependent on the study being undertaken.

For the purpose of this meta-study, the following sources were used to search for research reports:

- Inspec: Contains scientific literature in the areas of electrical engineering, electronics, physics, control engineering, information technology, communications, computers, computing, and manufacturing and production engineering spanning 3500 journals and 1500 conference proceedings from 1969 to the present.
- PsycINFO: Contains international literature in the areas of applied psychology, communication systems, developmental psychology, education psychology, experimental psychology, personality, physical and psychological disorders, physiological psychology, psychometrics, social psychology and sports psychology from journals, book chapters, dissertations, and technical reports. The database being used is from 2000 to the present.
- http://scholar.google.com: Google's Scholar search will be used to find further reports and citations.

The "file drawer" problem is common while conducting meta-studies. This problem refers to any research reports that exist but may not be found but would have given a significant contribution to the study. In order to minimize this problem we have included reports from many different disciplines, included reports from both journals and conference proceedings, and used Google Scholar to search for additional reports that may have been missed using more conventional methods.

Probably as a consequence of the topic being explored by researchers from a variety of backgrounds and disciplines, there is a lack of standardized use of terms pertaining to online trust. It is believed that such a lack of standardization makes it easy to miss important contributions when relying solely upon automatic searches. In addition, many of the obvious search terms are utilized in everyday speech and in a variety of contexts implying that automatic searches often return massive volumes of results. For example, if www.scholar.google.com is given the search term ("trust" AND "online") more than 4000 results are returned! Hence, it is believed that a more manual approach is required (reading titles and abstracts from a variety of search terms across a variety of search mediums) to identify a realistic initial starting point (104 papers in our case). Clearly, this approach has serious implications in terms of time commitment and in terms of the lack of provability that the search is complete. However, given the nature of the problem, it is believe that it offers the only realistic solution. While, clearly this process represents a serious threat to the validity of the study.

2.2.2 Criteria for Inclusion

There are many characteristics that can be used as criteria for inclusion of research information such as the discipline of the authors, demographics of the study population, publication date, or methodological characteristics [28]. The criteria used will be different depending on the research question and research approach. The primary research that is included should be congruent with what the meta-study is trying to accomplish.

For the purpose of this meta-study, the following criteria for inclusion were established:

- Reports must be published between 2001-2006 inclusively. The area of online trust is a fairly new field of research and thus the number of reports dealing with this idea decreases rapidly as the publication date recedes beyond this date. In addition, this period provides a sufficient volume of publications to meet the "size of study" requirement as described in Section 1.3.1.
- Reports must have been published in journals or conference proceedings; unpublished reports (including dissertations) are not included in this study. They are often difficult to find, as they are not included in databases, and often must be purchased. This makes it difficult to determine how many of the existing unpublished reports have been examined and how many have been missed. It also makes it difficult for a reader of this meta-study to independently verify the resources used within it. This practice is in common with approaches taken by other authors conducting meta-analytic reviews. For example, Jorgensen and Sheppard limit the scope of their search to "Journal publications only" when conducting a review of software development cost estimations approaches [60].
- Reports must contain an empirical study, which explores proposed theories and hypothesis. An empirical basis for the proposed theories is necessary in order to add validity to the research.
- Reports must examine the use of an online resource. All reports should fall under the topic area proposed in the meta-study research question in order to add value to this study.

- The study also excludes all reports where the empirical evidence contained in the report was previously published before 2001.

2.2.3 Criteria for Exclusion

There is disagreement among meta-study researchers as to what exclusion criteria should be used. Some researchers have argued that primary reports should not be excluded based on the quality of the research present in them as this can exclude data that may be useful in the meta-study [61]. However, Paterson et al suggests that there are some types of faults and inconsistencies in reports that can jeopardize the quality of the final meta-study [28]. These inconsistencies include using skewed samples or very small samples, omitting data or only using data that supports the theory stated in the report, arriving at conclusions not supported by the data, failing to account for data that is contained in the report, and obvious researcher bias. As all primary research reports for this meta-study are taken from peer-reviewed journals and conference proceedings, reports will not be excluded based on research quality.

2.2.4 Selected Primary Research

114 reports were initially retrieved via the method outlined in Section 2.2.1; of these 28 were identified as "valid for the meta-study" using the methodology outlined in Sections 2.2.2 and 2.2.3. The reports that were rejected for inclusion are listed in the references [12, 62-105] and [21, 106-145]. Of the reports chosen for the study, 20 of them were from journals and 8 were from conference proceedings. This "valid" sample is described in Table 1,

Table 1: Selected Primary Research Reports

Report Number	Title	Authors	Reference
1	Determining Success for Different Website Goals	L. C. Schaupp W. Fan F. Belanger	[44]
2	Measuring Online Trust of Websites: Credibility, Perceived Ease of Use, and Risk	C. L. Corritore R. P. Marble S. Wiedenbeck B. Kracher A. Chandran	[15]
3	Reflections on the Dimensions of Trust and Trustworthiness Among Online Consumers	D. Gefen	[37]
4	Personalization versus Privacy: An Empirical Examination of the Online Consumer's Dilemma	R. K. Chellappa R. G. Sin	[57]
5	Consumer's Acceptance of Internet Shopping: Intrinsic versus Extrinsic Motivations	R.-A. Shang Y.-C. Chen L. Shen	[32]
6	How Do Users Evaluate the Credibility of Web Sites? A Study with Over 2500 Participants	B.J. Fogg C. Soohoo D. R. Danielson L. Marable J. Stanford E. R. Tauber	[45]
7	A Framework for the Identification of Electronic Commerce Design Elements that Enable Trust within the Small Hotel Industry	R. T. Stephens	[43]
8	Re-Examining the Measurement Models of Success for Internet Commerce	J. C.-J. Chang G. Torkzadeh G. Dhillon	[39]
9	Trust and Mistrust of Online Health Sites	E. Sillence P. Briggs L. Fishwick P. Harris	[20]
10	Understanding User Perceptions of World-Wide Web Environments	S.-S. Liaw	[58]
11	Privacy Concerns and Internet Use – A Model of Trade-off Factors	T. Dinev P. Hart	[56]
12	On the Explanation of Factors Effecting E-Commerce Adoption	D. Lee J. Park J. Ahn	[31]
13	Applying the Technology Acceptance Model and Flow Theory	M. Koufaris	[40]

	to Online Consumer Behavior		
14	Affect of Trust on Customer Acceptance of Internet Banking	B. Suh I. Han	[18]
15	Factors Influencing the Adoption of Web-Based Shopping: The Impact of Trust	C. Van Slyke F. Belanger C. L. Comunale	[33]
16	Examining the Factors that Influence the Intentions to Adopt Internet Shopping and Cable Television Shopping in Taiwan	S.-C. Sarrina Li	[34]
17	An Extension of Trust and TAM Model with TPB in the Initial Adoption of On-line Tax: An Empirical Study	I.-L. Wu J.-L. Chen	[22]
18	A Web Assurance Services Model of Trust for B2C E-Commerce	S. E. Kaplan R. J. Nieschwietz	[16]
19	Internet Users' Information Privacy Concerns (IUPC): The Construct, the Scale, and a Causal Model	N. K. Malhotra S. S. Kim J. Agarwal	[26]
20	Consumer Acceptance of Virtual Stores: A Theoretical Model and Critical Success Factors for Virtual Stores	L.-d. Chen M. L. Gillenson D. L. Sherrell	[36]
21	E-Trust: The Influence of perceived Interactivity on E-Retailing Users	B. Merrilees M.-L. Fry	[41]
22	Strategies for Building and Communicating Trust in Electronic Banking: A Field Experiment	S. Y. Yousafzai J. G. Pallister G. R. Foxall	[19]
23	Trust in Online Advice	P. Briggs B. Burford A. De Angeli P. Lynch	[42]
24	Enticing Online Consumers: An Extended Technology Acceptance Perspective	L.-d. Chen M. L. Gillenson D. L. Sherrell	[35]
25	Trust Transfer on the World Wide Web	K. J. Stewart	[46]
26	Developing and Validating Trust Measures for E-Commerce: An Integrative Typology	D. H. McKnight V. Choudhury C. Kacmar	[59]
27	Privacy, Trust, and Disclosure: Exploring Barriers to Electronic Commerce	M. Metzger	[146]
28	Building Effective Online Marketplaces with Institution-Based Trust	P. A. Pavlou D. Gefen	[38]

The selected primary reports are taken from a range of disciplines and a range of areas of research. Table 2 shows the stated discipline of the primary research report authors along with the number of reports that have an author in that discipline. Note that one report may have authors from several different disciplines.

Table 2: Stated Discipline of Authors in Primary Reports

Discipline	Number of Reports
Information Systems	23
Marketing	8
Information Technology	4
Accounting	2
Communications	2
Industry	2
Information Management	2
Psychology	2
Business Management	1
Accountancy	1
Department of Business Administration	1
Engineering, Science, and Technology	1
Informatics	1
Information and Decision Sciences	1
Management Engineering	1
Persuasive Technology	1
Sociology of sports	1

Table 3 gives the areas of research for the primary research reports. Although the reports are from a wide range of research areas, over half of them examine e-commerce related areas. This is most likely due to the large growth in the e-commerce industry as well as the increased risk in providing personal and payment information during e-commerce transactions.

Table 3: Areas of Research for Primary Reports

Research Area	Number of Reports
E-Commerce	16
General Internet	4
Banking	2
Health	1
Information Disclosure	1
Online Advice	1
Online Auction Marketplaces	1
Online Taxes	1
Personalization Services	1

2.2.5 Assessment of Primary Research

The appraisal of reports accomplishes two tasks. The first task is to provide a tool to determine whether or not a primary report will be included in the meta-study. The second task is to accumulate the necessary data that will be used in the meta-study from the primary reports. Paterson et al [28] lists several aspects of primary reports that are significant to record, such as the theoretical framework and how it influenced the results, and details about the authors.

The following appraisal tool will be used in this meta-study. The tool contains the standards described by Kitchenham et al [147], information about the authors and theoretical framework as described by Paterson et al [28], as well as the findings from the primary reports. This template will be used in assessing all primary research reports as well as to collect the findings from the reports for further analysis.

Table 4: Evaluation Tool

Paper	
Paper Number	
Paper Type	

Authors	
Topic	Findings
Discipline of the authors.	

Experimental context	
Topic	Findings
As much of the context of the experiment as possible should be specified.	
If a hypothesis is being tested it should be stated prior to the study and the theory from which it is derived should be discussed.	
If the research is exploratory the questions it is suppose to answer should be stated before the data analysis.	
Research that is similar to or related to the current research should be described.	

Theory	
Topic	Findings
Conceptualization of the decision to use an online resource.	

Findings	
Topic	Findings
Elements of the model describing the use of an online resource (antecedents).	
Elements of the model describing the use of an online resource (consequences).	
Relationships between elements.	

Experimental design	
Topic	Findings
Define the population from which subjects where drawn.	
Define the selection process for subjects.	
Define the process for assigning subjects to treatments.	
Study designs should be simple or should be one that is fully analyzed in the literature.	
The experimental unit should be defined.	
A pre-experiment or pre-calculation should be performed to estimate the minimum sample size required for formal experiments.	
Appropriate levels of blinding should be used.	

The researcher should state any vested interest they have in the study, all sources of support, and what they have done to minimize bias.	
Controls should be avoided unless the control situation can be well defined.	
All treatments used should be fully defined.	
The relevance of the outcome measures should be justified.	

Conduct of the experiment and Data collection	
Topic	Findings
All measures that are used should be fully defined?	
A measure of inter-rater agreement (such as validity and reliability for questionnaires) should be presented for subjective measures.	
Quality control procedures that were used should be described.	
The response rate for surveys should be given along with a discussion of how representative the responses are.	
Information about subjects who drop out of the study should be given.	
Data should be given about any measures that could be adversely affected by the treatment.	

Analysis

Topic	Findings
Any procedures that are used to control for multiple testing should be described.	
Consider using blind analysis to avoid problems with "fishing for results".	
A sensitivity analysis should be performed on the data.	
Make sure the assumptions of the tests used are valid on the data set.	
Quality control procedures should be applied to verify the results.	

Presentation of results	
Topic	Findings
All statistical procedures (except for very simple ones) should be described or referenced.	
If a statistical package was used it should be reported.	
Quantitative results should be presented along with significance levels, the magnitude of effects, and the confidence limits.	
Raw data should be given if possible or the report should state that the data is available for review.	
The descriptive statistics used should be appropriate.	

The graphics used should be appropriate.	

Interpretation of results	
Topic	Findings
The population to which inferential statistics and predictive models apply should be defined.	
The researcher should differentiate between results that are real (statistically significant) and results that matter (practical significance).	
The type of study should be defined (confirmatory, exploratory).	
The limitations of the study should be described.	

2.2.6 Ensuring Rigor

Paterson et al describes several ways to ensure rigor in a meta-study [28].

- All processes used and decisions made should be thoroughly documented and their rational should be explained.
- The meta-study findings should be checked against the primary research to ensure that the meta-study contains both typical and atypical elements of the primary research..
- Alternate theories should be explored as alternative explanations the meta-study results.

The importance of working in a team to accomplish a meta-study is often repeated [28]. The different points of view provided by teamwork allow for different interpretations of the primary research and therefore greater rigor in the meta-study. Because much of this study will not be performed independently it is much more important that all decisions be rationalized and documented. This will allow readers of this meta-study to follow the processes and decisions of the researcher and determine how valid they were.

2.3 Data Analysis

Meta-data-analysis is the process of analyzing the data collected from primary research reports. In the case of this meta-study, the data collected from primary reports are the factors effecting the adoption of an online resource and the relationships between these factors. Paterson et al states that the researcher conducting the meta-study should "choose a data analysis strategy that fits with their research question and design, as well as the prevailing paradigm and their personal preference" [28].

At this stage of the analysis, we have the findings from the primary reports in the form of textual data that was extracted through the process defined in Section 2.2.5. It is necessary to synthesis this data into a comprehensive view of this field of research. A recent report published by the United Kingdom's Health Development Agency described common methods for synthesizing findings of qualitative and quantitative research which include several methods that can be used for textual data analysis [148]. These include grounded theory [149], thematic analysis [150], and content analysis [151]. Of these methods, the one that fit best with the research goals and data in this meta-study was content analysis. Content analysis is described as a method of categorizing data and then determining the frequency of the different categories [148]. Content analysis has a very well defined process, which makes the analysis transparent and easy to follow. Grounded theory and thematic analysis lack this transparency [148]. Reliability and validity can be calculated in content analysis [151]. This is important as it allows the researcher to insure that the results are meaningful.

2.3.1 Overview of Content Analysis

Kassarjian describes content analysis as an objective, systematic, quantitative, and reliable [151] approach to data analysis. Objectivity in the context of content analysis can be defined as "the extent to which categorization of sections of transcripts is subject to influence by the coders" [152]. In a study of content analysis research, several items are important for ensuring objectivity [153]:

- Rules and procedures are defined.
- Judge training should take place to familiarize judges with the coding scheme.
- The coding scheme should be pre-tested to check its reliability.
- Judges should be independent from the authors of the primary research reports.
- Judges should work independently.

Content analysis should be a systematic process [151, 152]. There are several guidelines that can be followed to insure this. Consistent rules should be applied when determining which samples or content categories to include or exclude [151]. The analysis should be examining a specific scientific problem or hypothesis [151]. The problem examined in this analysis is the research question stated in Section 1.2. A structured set of theories and methodologies should be used in the analysis [152].

According to Kassarjian, the analysis should be quantitative, which means that "the data [should] be amenable to statistical methods" [151]. Categories would therefore have a number associated with them that represents the frequency or count of the occurrence of that category in the data.

According to Kassarjian, two types of reliability should be estimated [151]:

- Category Reliability: the extent to which judges feel the data fits into the categories that have been defined.
- Inter-judge Reliability: the agreement between the judges as to which piece of data fits into which category.

Other researchers only suggest calculating inter-judge reliability [152, 154]. There are two ways that this can be calculated. The first method calculates the number of agreed upon coding decisions out of all coding decisions made [152]. This is calculated as follows (for two judges).

Equation 1: Coefficient of Reliability
$COR = 2 * m / (n_1 + n_2)$

Where:

m = number of agreed upon coding decisions

n_1 = number of coding decisions by the first judge

n_2 = number of coding decisions by the second judge

The second method for calculating inter-judge reliability is using Cohan's kappa (k) statistic [152]. The strength of this method is that it takes into consideration the probability that judges coding randomly would agree in their coding assignments. This is calculated by [155]:

Equation 2: Cohan's kappa statistic
$k = (F_O - F_C) / (1 - F_C)$

Where:

F_O = Expected agreement between judges

F_C = Probability that the judges agree by chance

F_C is calculated as [155]:

Equation 3: Decisions where agreement is expected by chance
F_C = sum $((n_i / N)^2)$ for i in 1…C

Where:

n_i = Number of items assigned to category i

N = Total number of items assigned to all categories

C = Total number of categories

The use of reliability in content analysis seems to vary widely with some research suggesting the over 30% of papers do not give a reliability coefficient [153] other research suggests the number is closer to 50% [152]. The values that reliability coefficients should be are mostly agreed upon though with reliability percentage values of above 80% [152] to 85% [151] required or a k value greater than 0.7 [154] to 0.75 [152].

Validity of the instrument is an important factor to examine however it can be difficult to determine when performing a content analysis [154, 156]. Kassarjian suggests that at a minimum the instruments appear valid using face validity (instrument looks like it will measure what it is suppose to) or content validity (instrument represents all areas of a concept) [151]. Both face validity and content validity are examined in this study.

2.3.2 Analysis Methodology

The process of conducting a content analysis involves several steps [151]. The first step is to define the data sampling procedures. The data sampling procedures have been defined in accordance with the structure suggested by the meta-study literature [28] and are outlined in Section 2.2. The second step is to define units of measurement or analysis [151, 152]. Units of analysis are the parts of the document that will be recorded and analyzed and may be anything from paragraphs to words or ideas [152]. The units of analysis are defined by our research question as one primary research report. This means that if a primary report contained a specific factor or relationship, that factor or relationship will be counted once for that report. The next step is to define categories of analysis. Kassarjian defines categories as the "conceptual schema" of the research [151]. Qualitative content analysis suggests developing the categorizing system based on the data being analyzed as opposed to starting with a pre-existing coding scheme [157]. Mayring suggests a deductive model to general categories with the following steps [154]:

- Determine the research question.
- Create categories using a theoretical basis.
- Create definitions, examples, and coding rules for the categories using a theoretical basis and collect them into a coding agenda.
- Revise the categories and coding agenda based on the data and calculate the reliability. If the reliability is low repeat the above steps.

- Analyze all data using the categories and coding agenda and calculate the reliability. If the reliability is low repeat the above steps.
- Interpret the results.

Each category should have a clear definition of what the category means, examples of the types of data that goes into that category, and coding rules for how to assign data.

The categories of analysis for this study will have two parts, relating to the two units of analysis above:

1. The first section of categories will be types of factors effecting adoption of online resources. These categories will consist of such items as expertise, ease of use, or integrity.
2. The second section of categories will be all possible relationships between the aforementioned factors.

Where quantitative content analysis usually stops after the tabulations of the categories, qualitative content analysis continues by interpreting the patterns found in the categories [157]. In other words, quantitative analysis asks what and how many; while qualitative analysis asks why and how.

One of the main limitations of this method is that the importance of results is neglected in favor of the frequency of results [148]. This imposes a limitation on this study as the results from different reports (of even within the same report) may have different levels of importance. Because of the large number of data collection and analysis methods used in the reports, it is not feasible to assign a level of importance to specific pieces of data.

Primary research reports will not be excluded based on the quality of the report (see Section 2.2.3). All primary reports as well as all data within the reports will be given equal importance so that each primary report will be counted in a specific category either zero or one times.

Several studies on the quality of content analysis in current research found that reliability and objectivity were seriously lacking [152, 153]. This finding suggests that care should be taken to insure that this study meets with acceptable standards of reliability and objectivity by following the guidelines outlined in previous qualitative content analysis research [151-154].

2.3.3 Categories of Analysis

Table 5 describes the categories and coding rules for coding factors effecting the adoption of websites and web services. The coding scheme was determined in the following way. First, the data was examined as well as current literature in the field in order to find reoccurring themes. These themes were developed into a preliminary set of categories along with definitions for them. These categories were then given to three judges who were familiar with the field to assess face validity (instrument appears valid) and changes were made as necessary. Examples and coding rules were then developed for the revised categories. Two judges then employed this coding scheme independently in pretests. This accomplished several objectives. The judges were given a chance to familiarize themselves with the use of the coding scheme and the coding scheme was adjusted throughout the process for clarity and validity.

Table 5: Categories of Analysis

Category	Definition	Examples	Coding Rules
Usefulness	Users' perceptions of how useful a website is in helping the users achieve their goals.	Usefulness of Information Perceived Effectiveness: The extent to which the user believes a website will be useful in helping to complete a task.	Anything describing how a website helps a user, is useful to the user, or adds value should be coded here.
Ease of Use	Users' perception of how easy a website is to use.	System Quality: The extent to which the user find a website easy to use to complete a task. Navigation: framework for providing viewers the information required to know where they are and a method of getting where they want to go, consistent treatment, placement, weight, and behavior of navigation web elements	Anything that effects how easy a website is to use should be coded here.
Risk	Users' perceptions of personal risks associated with use of the website.	Perception of risk Concern for Privacy	All factors that could be considered a risk to the user should be coded here.
Cognitive Enjoyment	How "fun" the user finds the website to use.	Cognitive Absorption: a measure of how fun the website is to use. Includes temporal dissociation, focused immersion, heightened enjoyment, control, and curiosity. Web enjoyment: how much users enjoy using the web and web technology	Any factors that indicate a user enjoys or has fun interacting with a website should be coded here.

Social Pressures	Peer pressure for a user to use a website (how "cool" it is to use).	Image: degree to which the use of the innovation is seen as enhancing to an individual's image or social status Subjective Norm: the perceived organizational or social pressure of a person while intending to perform the behavior in question (expectations of other persons)	Any factors that indicate outside (societal) pressures to use a website should be coded here.
Reputation	The opinion of external parties about the website.	Name Recognition and Reputation Unknown target signals association with trusted target	Any factor that indicates a 3rd party opinion should be coded here.
Integrity	Users' perceptions that the website will follow strict rules of conduct.	Faith in Humanity: integrity Honesty	If factors are broken down into sub-parts with one of the parts being integrity, honesty, or a related idea, the factor should be coded here.
Benevolence	Users' perceptions that the website will act according to the users' best interests. Benevolence is a website's motives or intentions toward the user. A website may not always follow all the rules but as long as it has the user's best interests in mind then the website is benevolent.	Faith in Humanity: benevolence Trust in Web Merchants: trustor's expectations about the motives and behaviors of a trustee	If factors are broken down into sub-parts with one of the parts being benevolence, intentions, or a related idea, the factor should be coded here.

Competence	Users' perceptions that the website possesses the necessary skills, knowledge, or ability to perform the required tasks.	Faith in Humanity: competence Credibility: demonstrates knowledge and expertise, appears impartial and ensures information is accessible	If factors are broken down into sub-parts with one of the parts being competence, ability, expertise, or a related idea, the factor should be coded here.
Trust	Users' perceptions of trustworthiness, or trust in, the website.	Initial trustworthiness of site Trusting beliefs regarding the unknown target	Code trust data into this category only if it is not broken down into integrity benevolence, and competence.
Predictability	The website conforms to the users' expectations.	Compatibility: degree to which an innovation is seen to be compatible with existing values, beliefs, experiences and needs of adopters Predictability: draws upon prior experience with this and other sites, reflects users' knowledge and understanding and contains the appropriate signs, statements or logos	Any factor indicating that a website operates as expected by the user should be coded here.
Use	The use of a website or online service or the intention to use a website or online service. This is the use of something not the perception of something.	Subjective Probability of Depending: follow advice, give personal information, make purchases Behavioral Intention to Use	All factors indicating action or intended action should be coded here (present or future actions).

Attitude	Users' feelings towards performing the specific task involved or interacting with the website.	Disposition to Trust: a general propensity to trust others Attitude toward Using: the consumer's attitude towards using the website	All factors relating to a user's attitude about using a website should be coded here. Factors indicating a personality trait (a disposition or propensity) should be coded here while factors indicating enjoyment of an action should be coded in Cognitive Enjoyment.
Ability	Users' ability to perform the necessary tasks or use the necessary technologies (computer literacy).	Technology experience: how experienced are users in using computer and web technology General Web Experience	Factors that relate to a user's expertise with using the web or a specific technology should be coded here.
Previous Actions	Users' previous actions or experiences under similar circumstances. Previous actions need to be based upon explicit actions undertaken by users and not analogous situations.	Bought: the customer has previously purchased something from the trusted party. Prior Web Purchase: indicates if the consumer has purchased online before	Factors that involve a user's actions or experiences with the Internet, websites, or other related technologies should be coded here (past actions). Factors indicating a user knows how to use a technology (hence the user has used the technology before) should be coded in Ability and not in

			Previous Actions as Ability may often be directly influenced by Previous Actions.
Demographics	Any demographical characteristics of the users.	Demographics: age, sex, education, and family income but not personal income Access to a credit card: indicates if the consumer has access to payment methods	All factors that indicate a physical attribute of the user should be coded here.
Innovativeness	How positive a user feels about using a new technology.	Innovativeness: an individual's tendency to seek novelty or to be more receptive to new ideas Personal Innovativeness: reflects confidence or optimism regarding adoption of new ideas or technologies	Any factor indicating the adventurousness of a user or how likely a user is to try something new should be coded here.

Each pretest consisted of 4 reports and two judges independently coded the data from them. The reports used in the pretests are shown in Table 6. Note that because of the small number of primary research reports available in the study, the same reports were used in Pretest 1a and 1b.

Table 6: Reports used in pretests

Pretest	Title	Author	Reference
1a, 1b	Commitment, Trust, and Social Involvement: An Exploratory Study of Antecedents to Web Shopper Loyalty	Jason Bennett Thatcher Joey F. George	[158]
1a, 1b	A Trust Model for Consumer Internet Shopping	Matthew K. O. Lee Efraim Turban	[159]

1a, 1b	Consumer trust in an Internet store	Sirkka L. Jarvenpaa Noam Tractinsky Michael Vitale	[24]
1a, 1b	E-commerce: the role of familiarity and trust	David Gefen	[27]
2	Perils of Internet Fraud: An Empirical Investigation of Deception and Trust with Experienced Internet Consumers	Stefano Grazioli Sirkka L. Jarvenpaa	[160]
2	Web Technology Adoption and Knowledge Barriers	Satish Nambisan Yu-Ming Wang	[161]
2	What makes Internet Users visit Cyber Stores again? Key Design Factors for Customer Loyalty	Jungwon Lee Jinwoo Kim Jae Yun Moon	[162]
2	The adoption of Internet-based stock trading: a conceptual framework and empirical results	Lawrence Loh Yee-Shyuan Ong	[163]

The results of the pretests are shown in Table 7. Inter-judge reliability was calculated using the coefficient of reliability and the Kappa statistic (see Formula 1, 2, and 3). Additionally category reliability was examined. This was calculated by adding an "Other" category to the above coding scheme. Judges coded data into this category if they felt it did not fit into any other category. Category reliability was then calculated as the total number of coding decisions not in the "Other" category divided by the total number of coding decisions. After each pretest was completed, both judges reviewed all coding decisions that were not in agreement. Based on this review the descriptions and coding rules for the categories of analysis (see Table 5) were updated to make them clearer to the judges.

Table 7: Pretest Reliability Results

Pretest	Inter-judge Reliability		Category Reliability
	Kappa Statistic	Coefficient of Reliability	
1a	0.74	76%	91%
1b	0.80	82%	95%
2	0.87	89%	98%

After Pretest 2 was complete the coding scheme was determined to be of sufficient reliability to continue with the main data coding.

2.3.4 Analysis Results

The coding for the content analysis of the 28 primary research reports was performed using the same methods as in the pretests. Two judges coded the primary reports independently using the coding scheme given in Table 5. The reliability results are shown in Table 8. Both the inter-judge reliability and the category reliability are at acceptable levels.

Table 8: Analysis Reliability Results

Inter-Judge Reliability		Category Reliability
Kappa Statistic	Coefficient of Reliability	
0.83	85%	99%

2.3.4.1 Model Visualization

Performing a content analysis on the data from the 28 primary research reports gave count values for each of the 18 categories as well as count values for the relationships between the categories.

The count values for the categories are shown in the Figure 1 while the cumulative category counts are shown in Figure 2. Both graphs show a very smooth trend with no obvious cutoff point apparent for categories that have little effect on the model.

Figure 1: Category Count Histogram

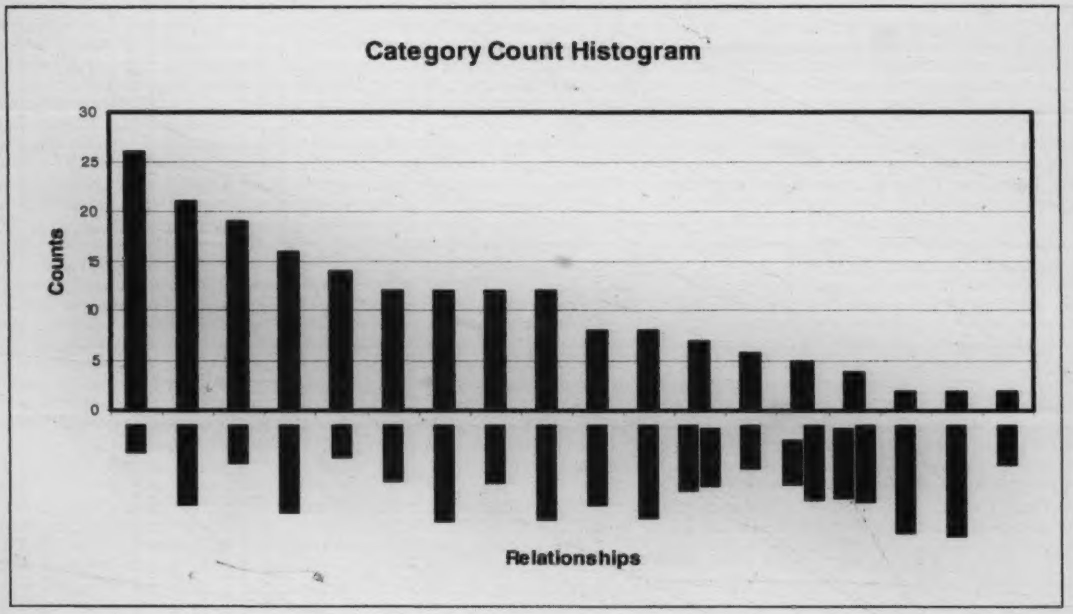
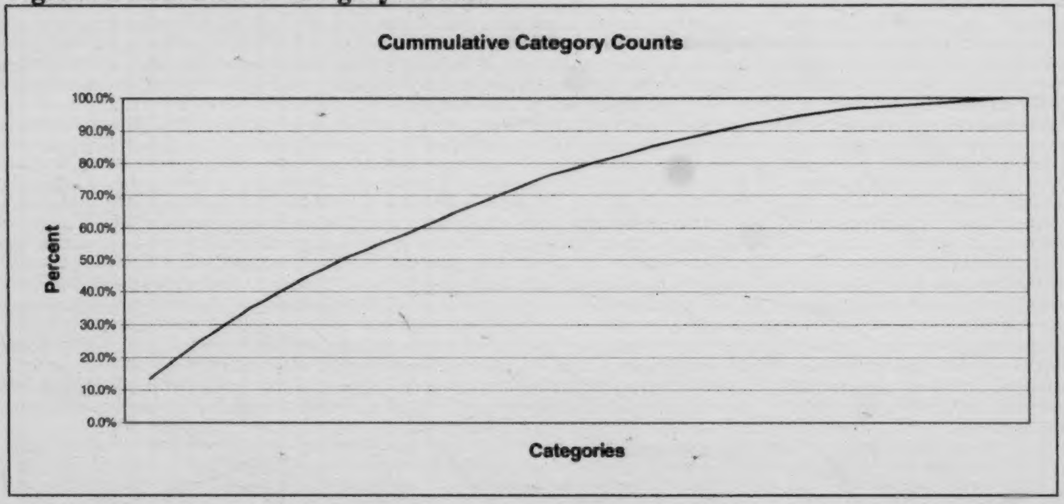

Category Count Histogram
30
25
20
15
10
5
0
Counts
Relationships

Figure 2: Cumulative Category Counts



Only 165 relationships had counts associated with them. These relationships were of four distinct types, positive effect, negative effect, positive correlation, and negative correlation. Reports numbered 2 and 8 were excluded from this analysis because there was not enough information to determine the types of relationships present in the research. The counts for the positive effect relationships are shown in Figure 3 and the cumulative positive effect relationship counts are shown in Figure 4.

Figure 5 and Figure 6 show these graphs for negative effect relationships. Again, all these graphs are very smooth with no apparent cutoff point for positive or negative effect relationships that have little effect on the model.

Figure 3: Positive Effect Relationship Count Histogram

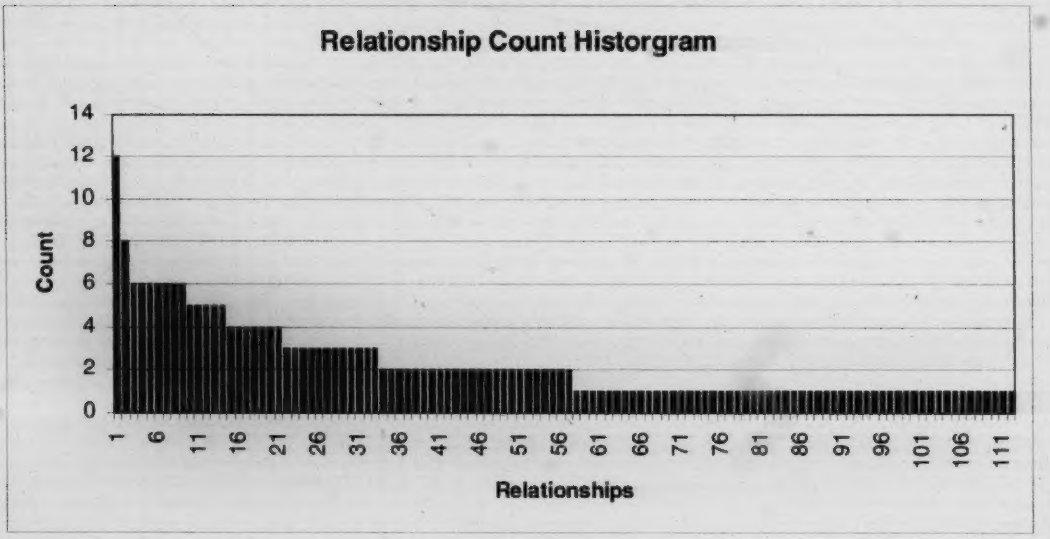

Relationship Count Historgram
14
12
10
8
6
4
2
0
Count
1
6
11
16
21
26
31
36
41
46
51
56
61
66
71
76
81
86
91
96
101
106
111
Relationships

Figure 4: Cumulative Positive Effect Relationship Counts

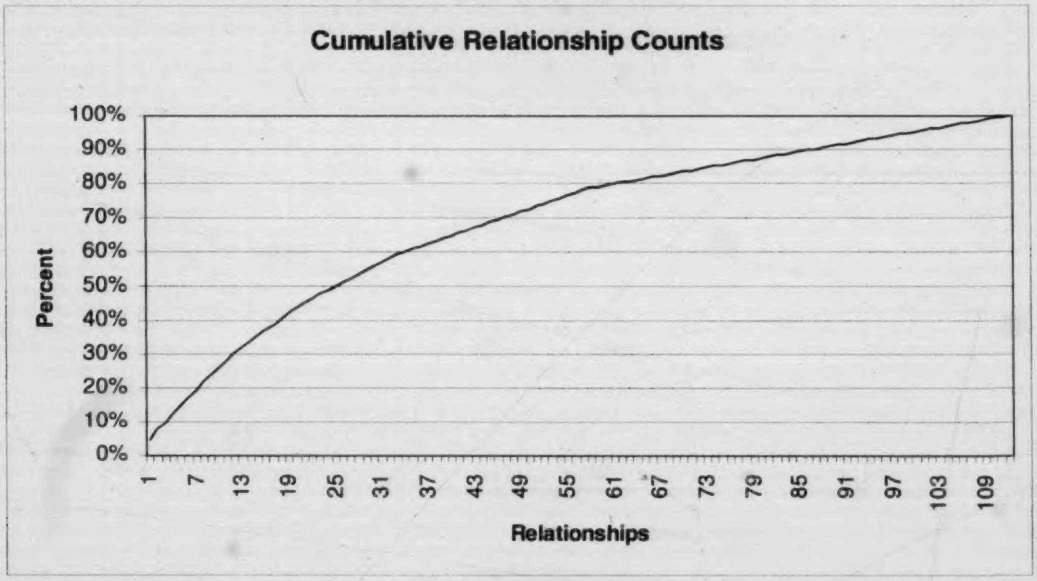


Figure 5: Negative Effect Relationship Count Histogram

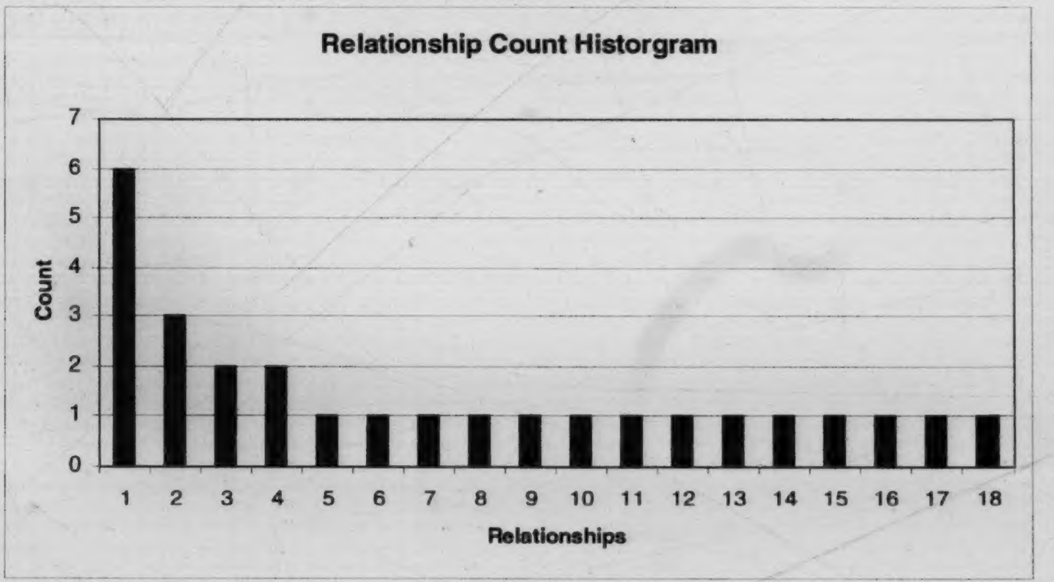


Figure 6: Cumulative Negative Effect Relationship Counts

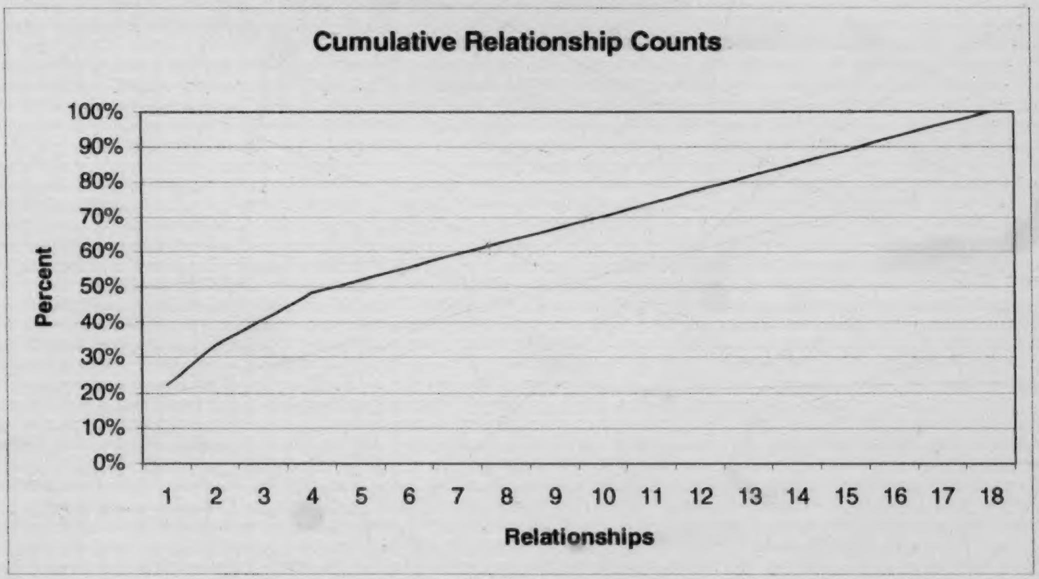
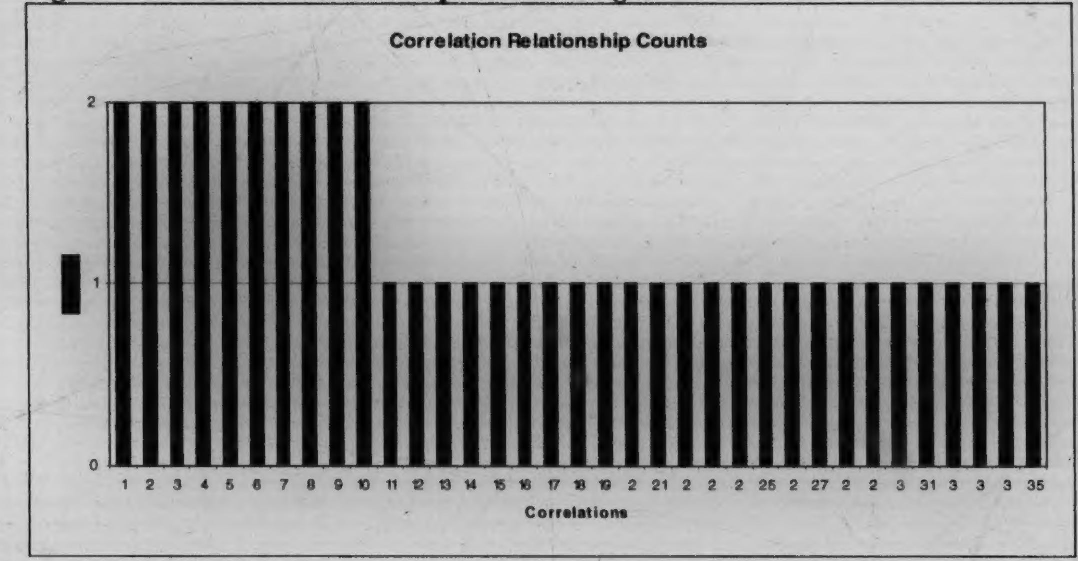


Figure 7 shows the count values for the correlation relationships. There are only 35 correlation relationships and they all have a count of either 2 or 1. Because of the low number of relationship of this type and the low count values associated with them, a detailed analysis will not be performed on the correlation relationships.

Figure 7: Correlation Relationship Count Histogram



The data will be visualized using a graph with the factors represented as weighted nodes and the relationships as directed weighted edges. It is necessary to examine positive and negative effect relationships separately in order for the graphs to have edges of a homogeneous nature. The high number of factors and relationships makes an attempt at visual representation of the complete data set a somewhat futile venture. Figure 8 shows the model with all factors and all positive effect relationships included. This graph contains 18 nodes and 112 relationships. Half of these relationships have a weighting of 1 while only 19% have a weighting of 4 or greater. The large number of relationships with very low weights makes it difficult to use the results in a meaningful way. For example, it would be difficult for the creator of an e-commerce site to use this model to design the site. For this reason, the data will be examined in smaller, more meaningful, subsets.

Figure 8: Complete View

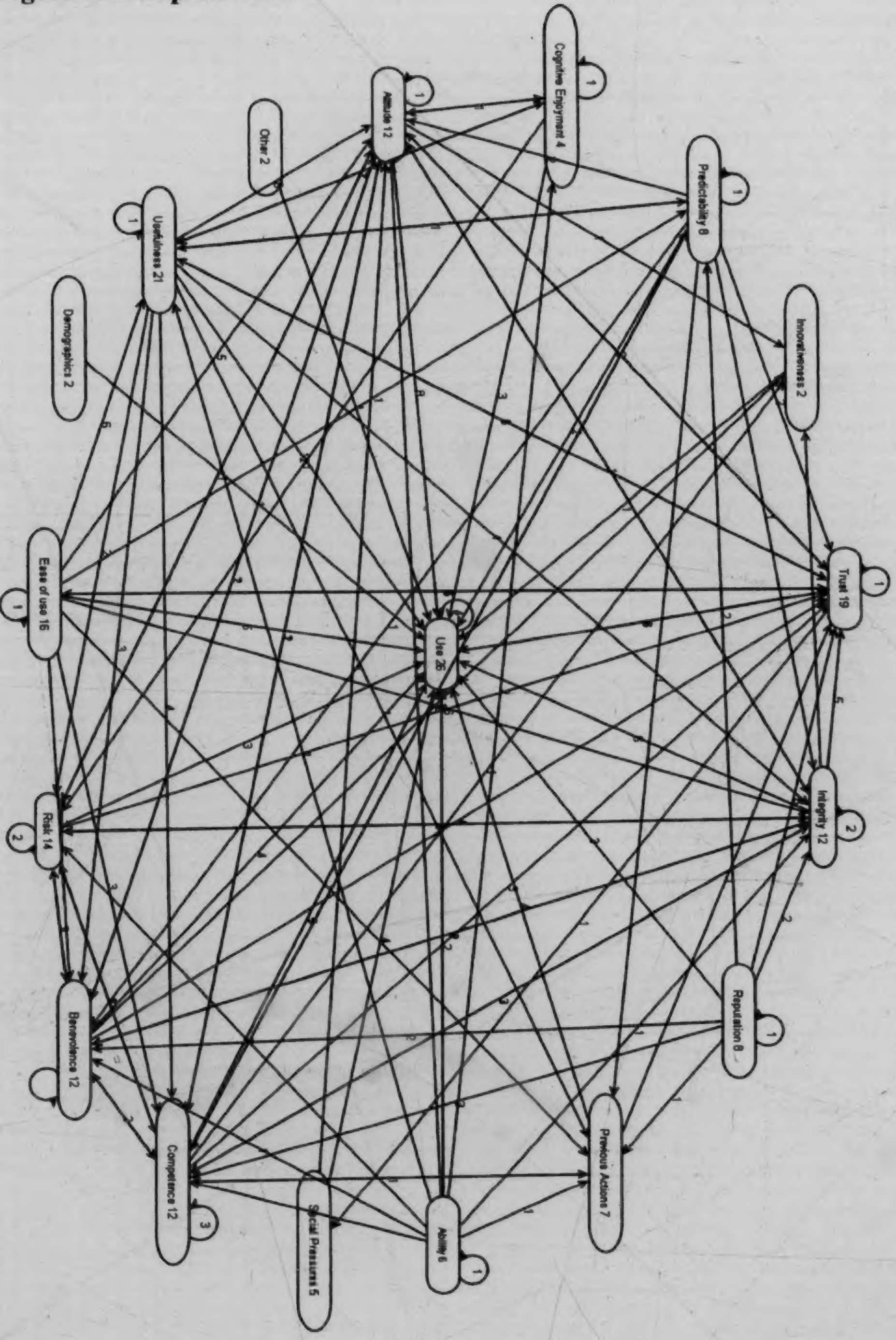

Cognitive Enjoyment 4
Attitude 12
Other 2
Predictability 8
Usefulness 21
Demographics 2
Innovativeness 2
Ease of use 16
Trust 19
Use 26
Risk 14
Integrity 12
Reputation 8
Benevolence 12
Competence 12
Previous Actions 7
Social Pressures 5
Ability 6

Table 9 shows the factors rankings as antecedents and consequences. The sum of weights into a node indicates how it behaves as an antecedent and the sum of weights out of a node indicates how it behaves as a consequence. The factors that are the strongest consequences are Use, Trust, Competence, and Attitude, all having a value of 25 or over. The factors that are the strongest antecedents are Usefulness and Ease of use with Competence, Integrity, and Risk all tying for 3rd place with a value of 21.

Table 9: Factors as Antecedents and Consequences for Complete Graph

Factor	Weights Out	Weights In
Ability	13	1
Attitude	17	25
Benevolence	16	18
Cognitive Enjoyment	8	5
Competence	21	26
Demographics	1	0
Ease of use	31	2
Innovativeness	1	4
Integrity	21	19
Other	2	0
Predictability	12	6
Previous Actions	6	6
Reputation	20	1
Risk	21	11
Social Pressures	5	1
Trust	12	42
Use	6	75
Usefulness	41	12

In order to view subsets of the graph, it is necessary to removed nodes and the edges connected to the nodes without damaging the integrity of the graph. There are several factors relating to the nature of the data that must be taken into consideration:

- If we have nodes A, B, and C and edges (A, B) and (B, C) with weights w_{AB} and w_{BC} then we will assume that there is an indirect effect on node C from node A with weight $w_{AC'}$ which must be considered when removing node B.
- The indirect relationship edge weight $w_{AC'}$ should not be greater then direct relationship edge weights w_{AB} or w_{BC}.
- A relationship edge with weight w_{AC} may already exist.

With these considerations in mind a formula was developed for calculating a new weight for edge (A, C) given the above situation. In the following formula, *r* is a ratio that reflects the perceived strength of the indirect relationship and should be in the range [0,1].

Equation 4: Edge Weight Adjustment

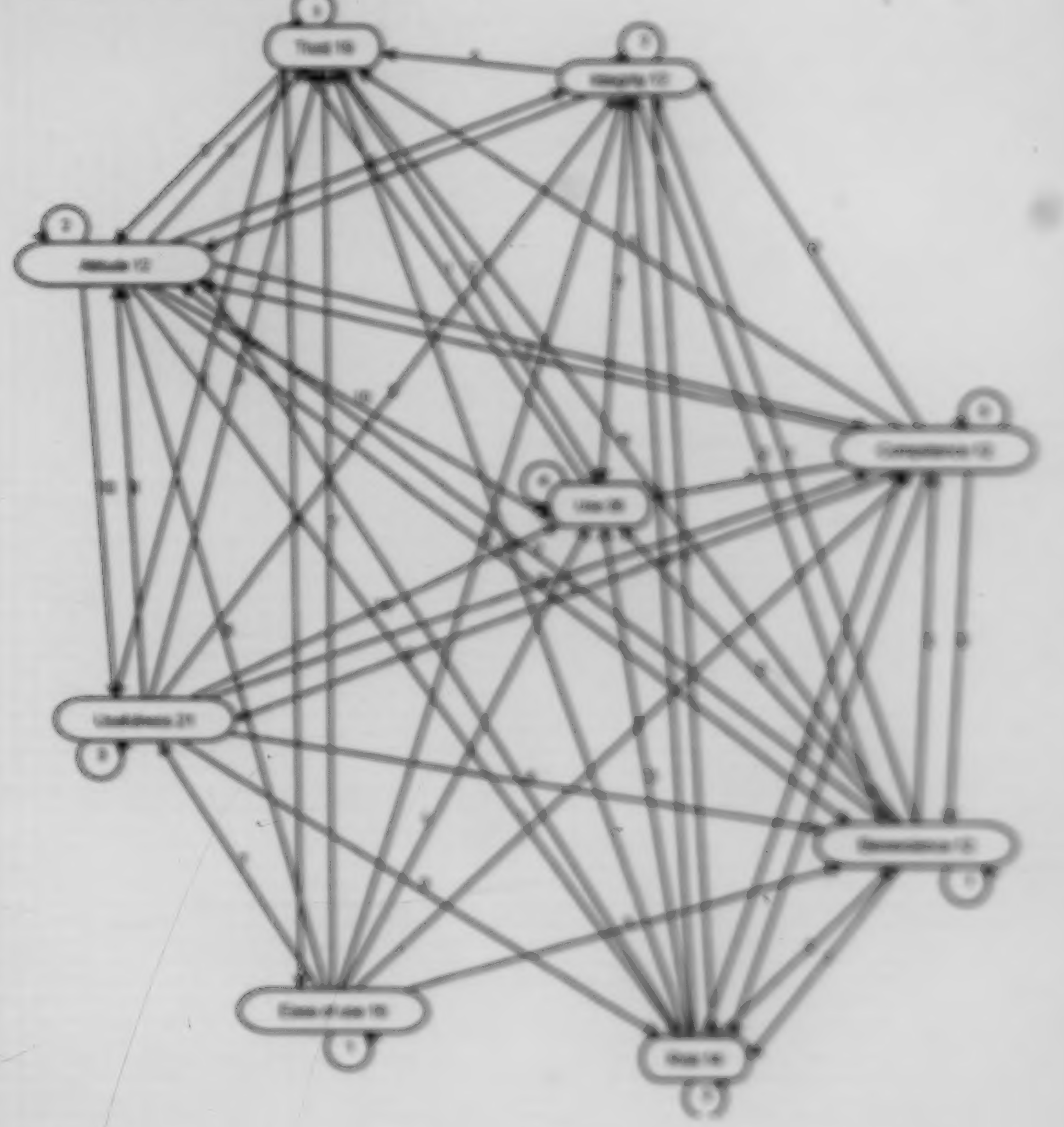
$$w_{AC_{new}} = w_{AC_{old}} + r * min(w_{AB}, w_{BC})$$

Ideally, the domain of interest should define *r*, but we have no clear insight into any appropriate empirical "facts" which could form a basis for this value. Hence, this analysis will simply set $r = 1$. The above formula will be applied for each pair of nodes A and C where edges (A, B) and (B, C) exist and node B is being removed.

2.3.4.1.1 Simplified Views

An exploratory examination of several simplified views of the complete model will now be performed to look for major trends that may come to light as some of the lower weighted nodes and edges are removed. Only the positive effect relationships will be used here. The negative effect relationships will be analyzed separately as there are very few relationships of this type. The negative relationships are discussed further in Section 2.3.4.1.3. The first simplified view to be examined is taking a cutoff point of 8 for the factor list. Choosing any cutoff point is somewhat arbitrary, however because this is an exploratory analysis it is of interest to examine a more simplified view of the system. The count value of 8 was chosen because there is a large jump to the next highest ranked factors (count value of 12) and it leaves enough factors to make the analysis of interest. This removed the following factors from the model: Reputation, Predictability, Previous Actions, Ability, Social Pressures, Cognitive Enjoyment, Demographics, Innovativeness, and Other. Formula 3 was used to adjust the edge weighting on the graph.

Figure 9: Model with Factor Cutoff of 8



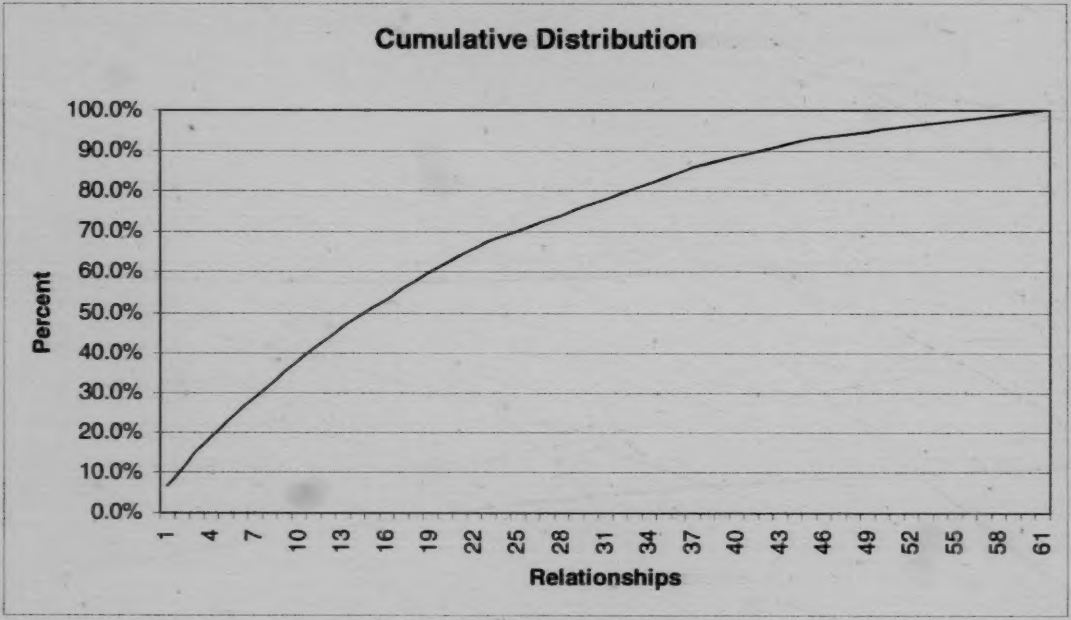
This simplifies the model from 112 positive affect relationships to 61 positive affect relationships. As can be seen from Table 10, this simplification did not make significant changes to which factors were most important as antecedents and consequences in the model. This suggests that the integrity of the model has been preserved. There is however one significant difference that should be noted. Attitude has risen from the 7th highest antecedent in the complete model to the 4th highest antecedent. This suggests that lower ranking factors have a large effect through Attitude on other factors in the model.

Table 10: Factors as Antecedents and Consequences for Factor Cutoff of 8

Factor	Weights Out	Weights In
Attitude	29	26
Benevolence	16	17
Competence	31	26
Ease of use	39	2
Integrity	21	18
Risk	21	10
Trust	13	39
Use	6	66
Usefulness	52	24

To further simplify the model, less significant relationships will be removed from the graph. Figure 10 shows the cumulative distribution of the relationships. Initially a cutoff value of 80% was chosen, however it lays part way through the relationships with weights of 3. Removing all of these relationships would give a cutoff value of 68% and leave 23 relationships while keeping all these relationships would give a cutoff value of 86% and leave 37 relationships. Because it does not make sense to remove only a few of the relationships with weights of 3, all of them will be removed in one graph and none of them will be removed in other. This will give two graphs with cutoffs of 68% and 86%.

Figure 10: Cumulative Distribution of Relationships with Factor Cutoff of 8



The two models with relationship weight cutoffs of 86% and 68% respectively can be seen in Figure 11 and Figure 12. Each model gets progressively simpler as less weighted relationships are removed. It is important to note that these models are not valid graphs. The graphs have had 14% and 32% respectively of the edge weights removed from them, which can make a significant impact on the overall model. However, it does help to bring to light the most significant relationships in the model. For example, of the original 11 relationships that involved risk in Figure 9, all but one of them has been removed in Figure 12. Although there were many small relationships involving Risk, the only major relationship was Risk's effect on Trust.

Figure 11: Model with Factor Cutoff of 8 and 86% of Relationship Weight

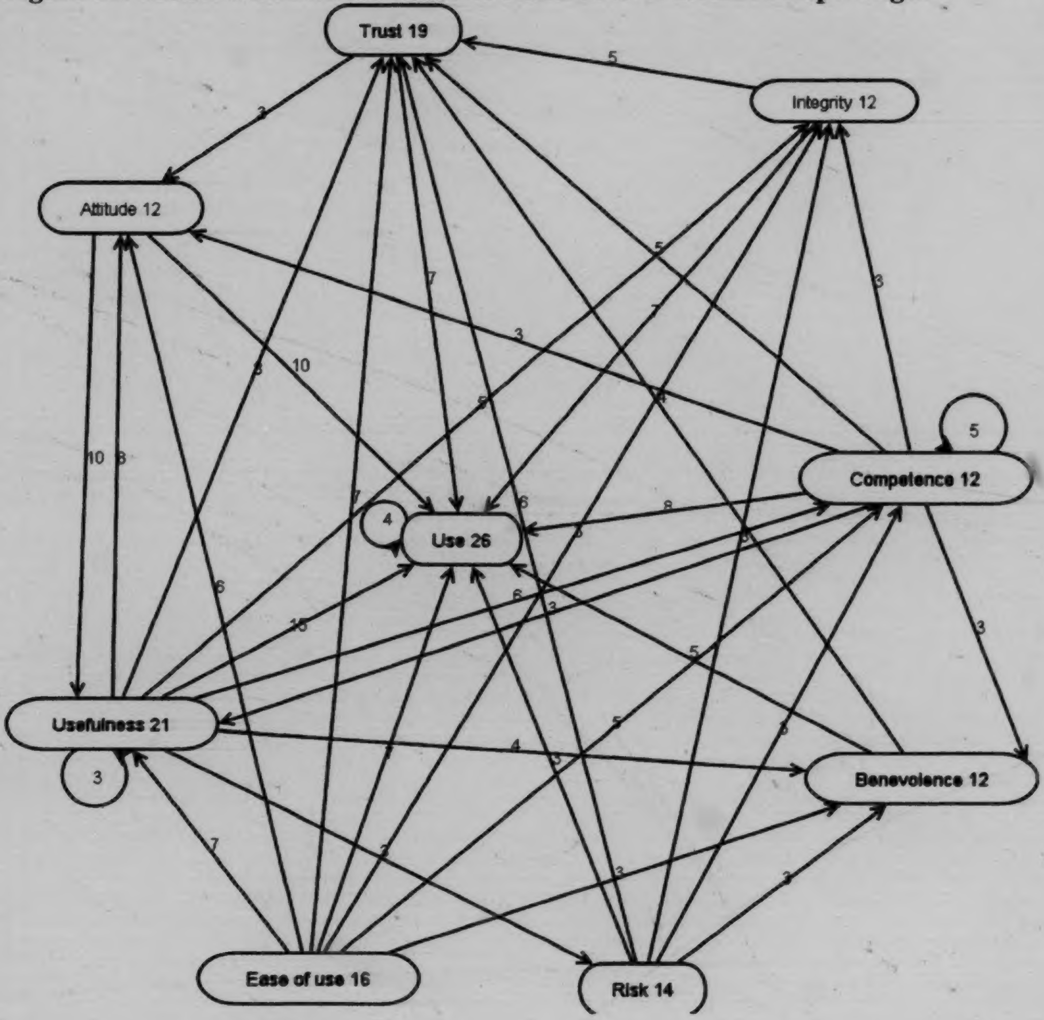
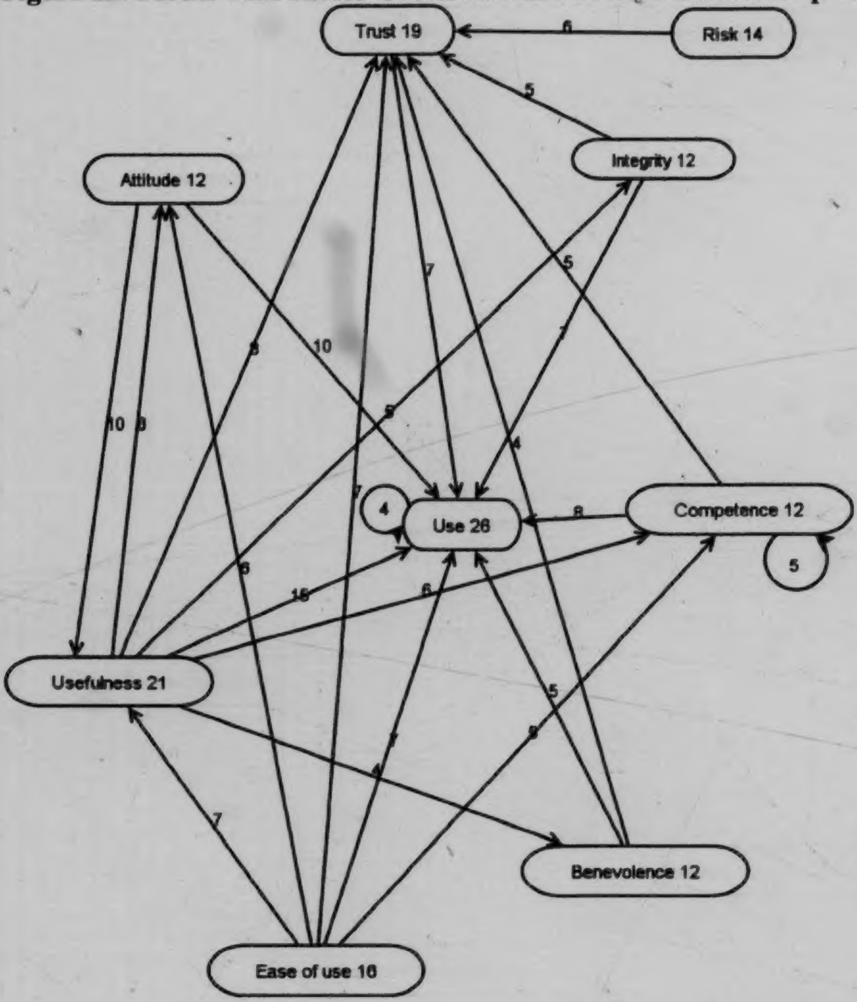
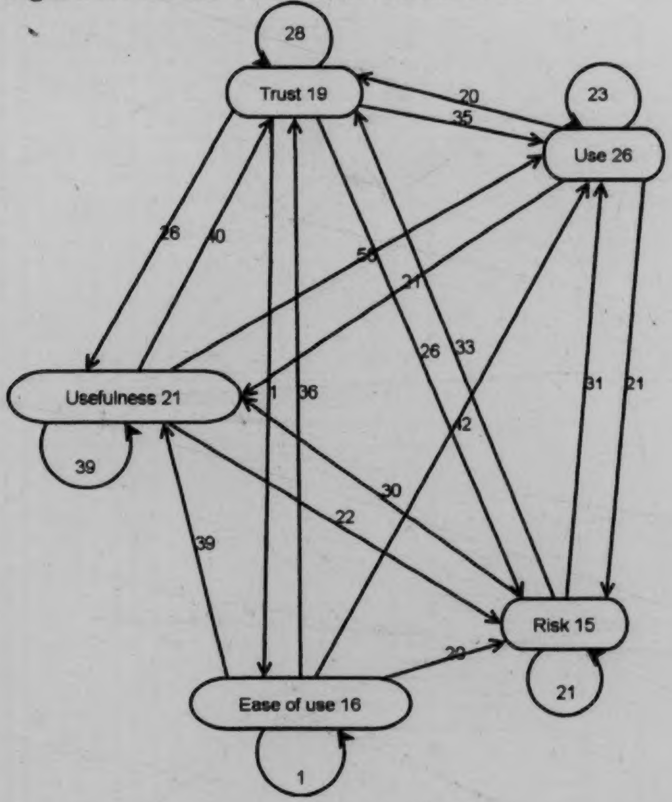

Trust 19
Integrity 12
Attitude 12
Competence 12
Use 26
Usefulness 21
Benevolence 12
Ease of use 16
Risk 14
5
3
5
7
3
3
10
10
8
5
4
5
4
8
6
7
6
3
15
6
3
5
3
5
5
4
3
3
7
3
3
3
3

Figure 12: Model with Factor Cutoff of 8 and 68% of Relationship Weight


Trust 19
6
Risk 14
5
Integrity 12
Attitude 12
7
5
7
8
10
8
10
8
4
7
4
Use 26
8
Competence 12
5
6
15
6
Usefulness 21
5
8
7
4
7
Benevolence 12
Ease of use 16

The next simplified view that will be examined is using a cutoff value of 12 for the factors. This removes the following factors from the model: Attitude, Competence, Benevolence, Integrity, Reputation, Predictability, Previous Actions, Ability, Social Pressures, Cognitive Enjoyment, Demographics, Innovativeness, and Other.

Figure 13: Model with Factor Cutoff of 12


28
Trust 19
20
35
23
Use 26
26
40
56
21
26
33
Usefulness 21
1
36
31
21
42
39
30
22
39
Risk 15
29
21
Ease of use 16
1

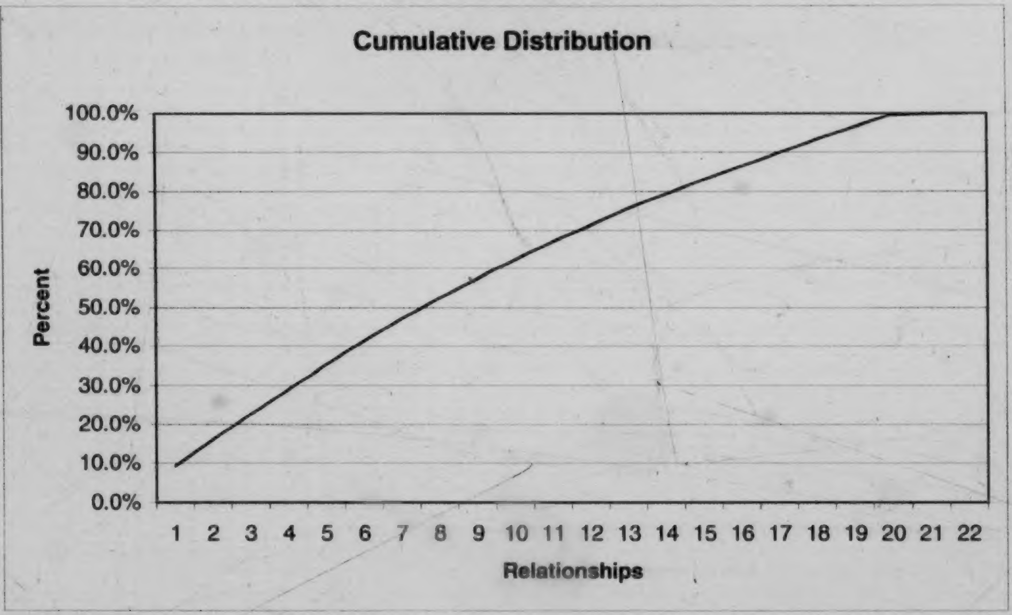
This simplification has taken the number of positive effect relationships from 112 down to 22. Table 11 shows the factors' values as antecedents and consequences for this simplified model. Although Use and Trust are still the strongest consequences, Usefulness is now the 3rd strongest consequence, which is up from 7th place in the complete model. Usefulness and Ease of use are still the 2 strongest antecedents. However, Trust has risen from 10th place to 3rd place as an antecedent. Trust had 7th place as an antecedent in the simplified model with a factor cutoff of 8. The large jump was due to the removal of Integrity, Benevolence, and Competence with the factor cutoff of 12. These three factors are often seen as subsets of Trust in research [7]. The large increase in position as an antecedent of Trust suggests that Attitude, Integrity, Benevolence, and Competence have a large indirect effect on other factors through Trust.

Table 11: Factors as Antecedents and Consequences for Factor Cutoff of 12

Factor	Weights Out	Weights In
Usefulness	157	155
Use	85	187
Trust	116	157
Risk	115	110
Ease of use	138	2

Figure 14 shows the cumulative distribution of the remaining relationships. An obvious cutoff point for removing less significant relationships would be to remove the two relationships with weights of 1. This would leave 99.7% of the relationship weight in the model. Using a cutoff value of 83% would leave the model with 15 relationships.

Figure 14: Cumulative Distribution of Relationships with Factor Cutoff of 12



The models resulting from taking relationship weight cutoff values of 99.7% and 83% respectively are shown in Figure 15 and Figure 16. Of the 7 relationships removed in Figure 16, three of them were from Use and 2 of them were to Ease of use. Use has the smallest strength as an antecedent and Ease of use has the smallest strength as a consequence in this model.

Figure 15: Model with Factor Cutoff of 12 and 99.7% of Relationship Weight

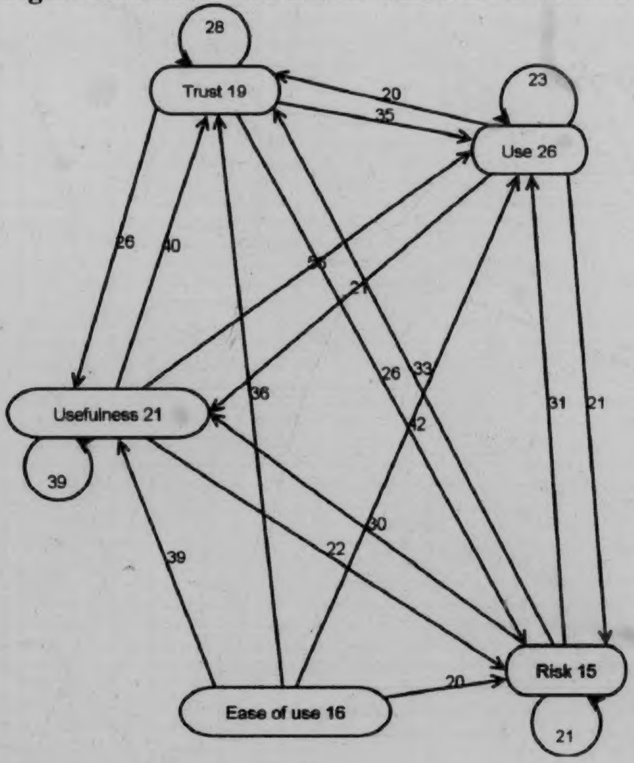
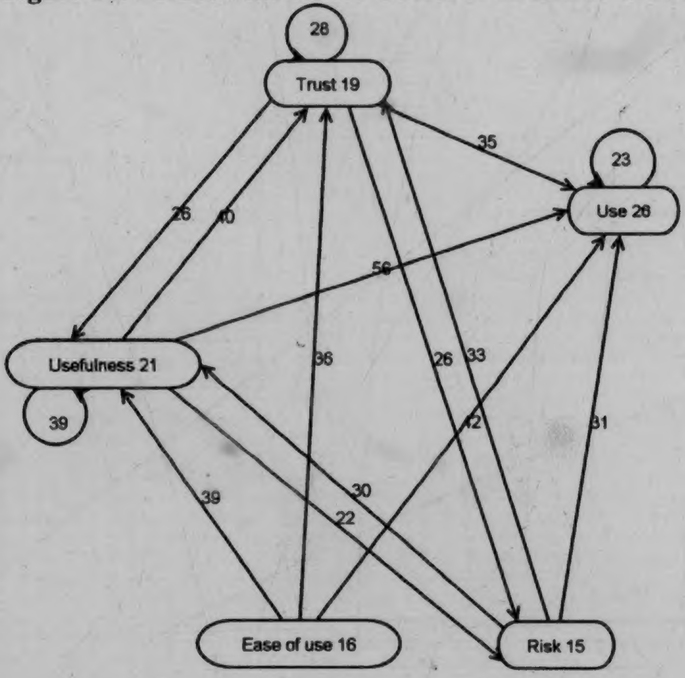

28
Trust 19
20
35
23
Use 26
26
40
56
27
26
33
36
42
31
21
Usefulness 21
39
30
22
39
20
Risk 15
Ease of use 16
21

Figure 16: Model with Factor Cutoff of 12 and 83% of Relationship Weight



Removing some of the lower ranked factors and relationships has given a better understanding of the over all model and the interaction between factors. Many of the factors are attributes of the user and therefore cannot be effected by the developer or operator of a web service. These may be things like user demographics, a user's predisposition to trust, or a user's ability level. Although these factors are important to understand, they cannot be built into a web system. The next view that will be examined will look only at the factors that a web developer or operator can build into a web system.

2.3.4.1.2 System View

The system view of the model is taken by removing all factors that cannot be built into a system. These factors consist of personal attributes of the user and the Other category.

The category Other is essentially an error category for items that could not be coded elsewhere. This category does not have a significant impact on the model as it does not contain homogeneous items. The factors that are considered personal attributes of the user are: Social Pressures, Attitude, Previous Actions, Ability, Demographics, and Innovativeness. Only positive effect relationships are considered. Figure 17 shows the system view of the model. This model is still very complex. It contains 84 relationships down from the 112 found in the original model.

Figure 17: System View of Model

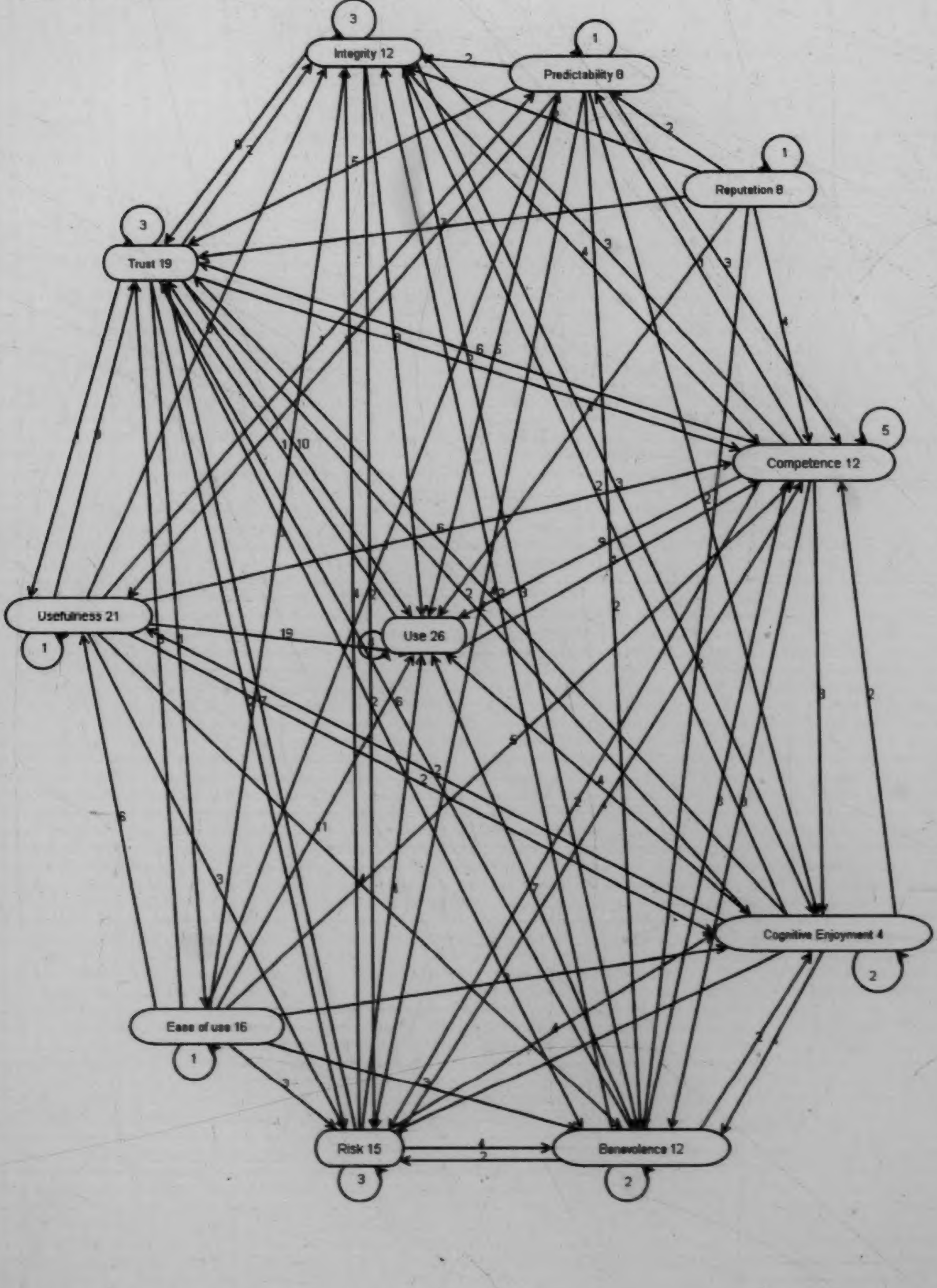

Integrity 12
3
Predictability 8
1
Reputation 8
1
Trust 19
3
Competence 12
5
Usefulness 21
1
Use 26
Cognitive Enjoyment 4
2
Ease of use 16
1
Risk 15
3
Benevolence 12
2

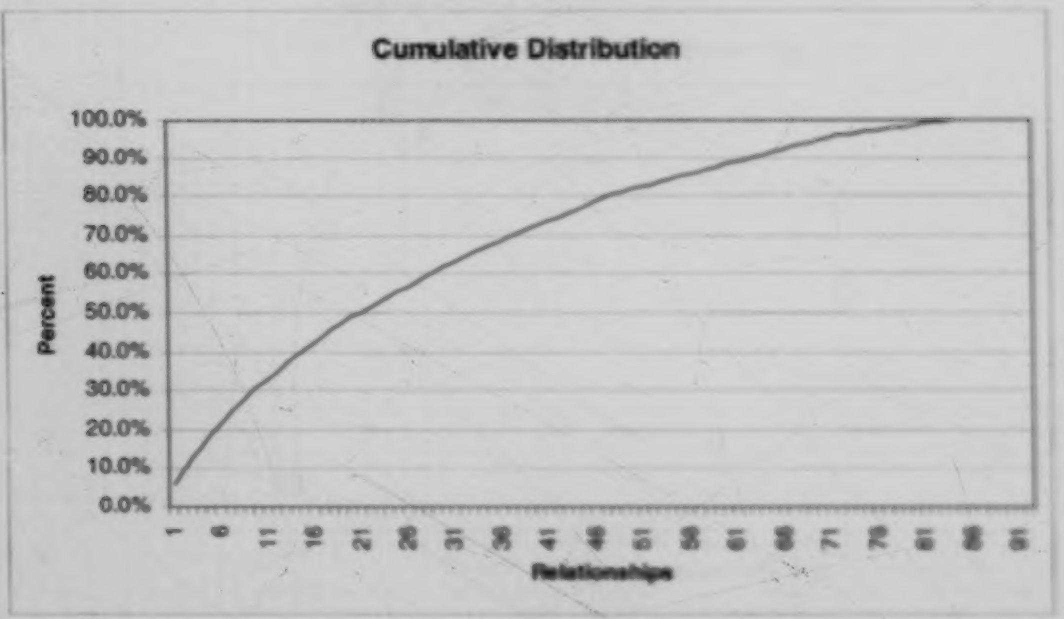
Table 12 shows the factors' values as antecedents and consequences for the system view. The factors strongest as consequences (Use, Trust, and Competence) and the factors strongest as antecedents (Usefulness, Ease of use, Competence) are very similar to the complete model. It is of interest to note that all of the factors except for Use act as fairly strong antecedents while just over half of the factors act as strong consequences (with Usefulness, Predictability, Ease of use, Reputation, and Trust being weak consequences). The complete model did not have this difference between the number of strong antecedents and strong consequences.

Table 12: Factors as Antecedents and Consequences for System View

Factor	Weights Out	Weights In
Usefulness	50	11
Use	6	85
Trust	25	62
Risk	30	21
Reputation	22	1
Predictability	23	6
Integrity	29	28
Ease of use	44	2
Competence	32	39
Cognitive Enjoyment	22	23
Benevolence	24	29

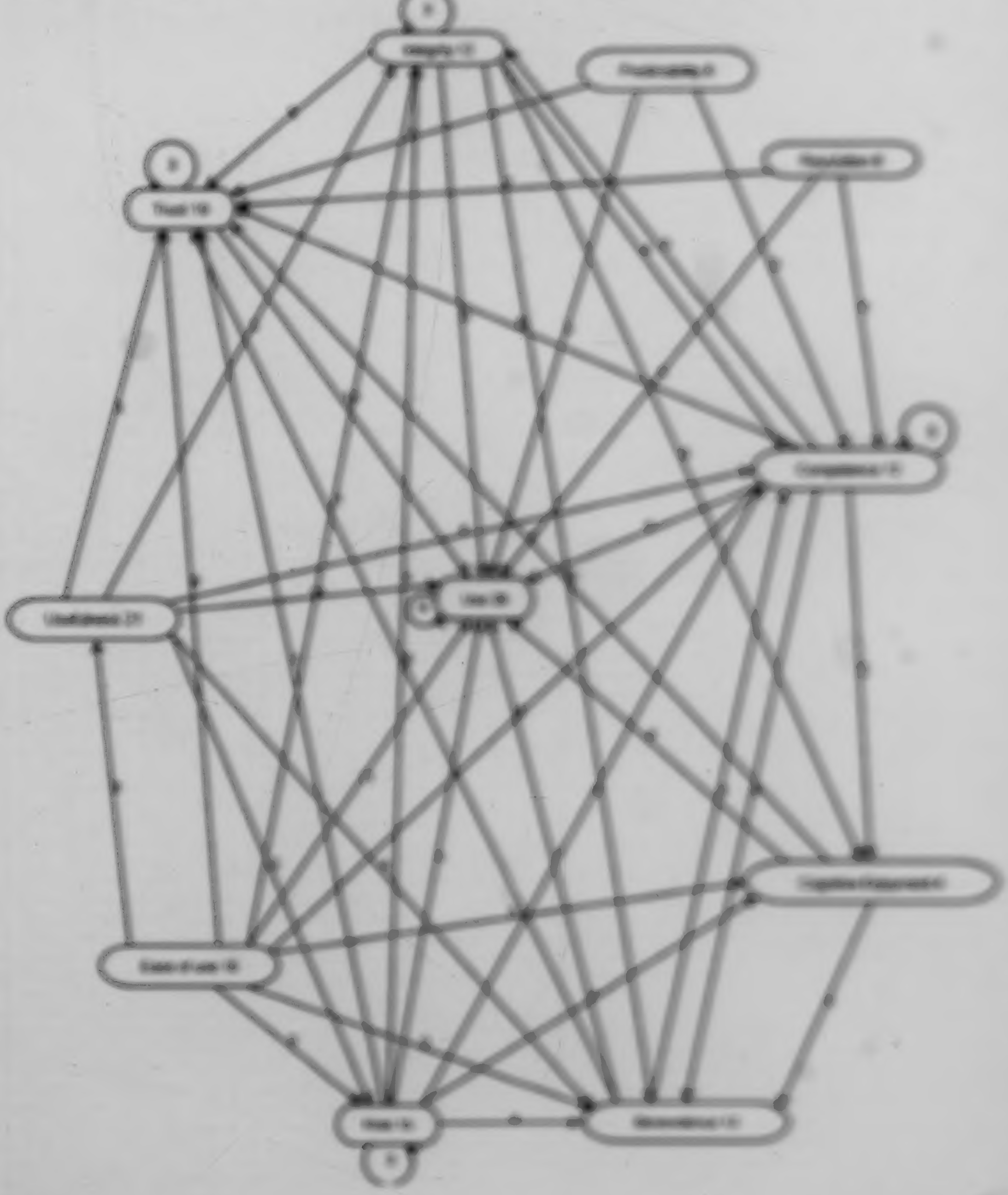
The cumulative distribution of the weighting of these relationships is shown in Figure 18. In order to further simplify the model, less significant relationships will be removed. As with the previous models, a cutoff point of 80% of the cumulative relationship weights was chosen. This cutoff point effectively removes all relationships with weights less than 3, leaving 48 relationships in the model.

Figure 18: Cumulative Distribution of Relationships in System View



The system view of the model with the relationship weights cutoff at 80% is shown in Figure 19. Many of the factors removed to make the system view (Previous Actions, Innovativeness, Demographics, Ability) had very few relationships associated with them. This has resulted in the system view being very complex. The weights of the relationships are fairly evenly distributed so even after removing the smallest relationships the model is difficult to visualize.

Figure 19: System View of Model with 80% of Relationship Weight



2.3.4.1.3 *Negative Effect Relationships View*

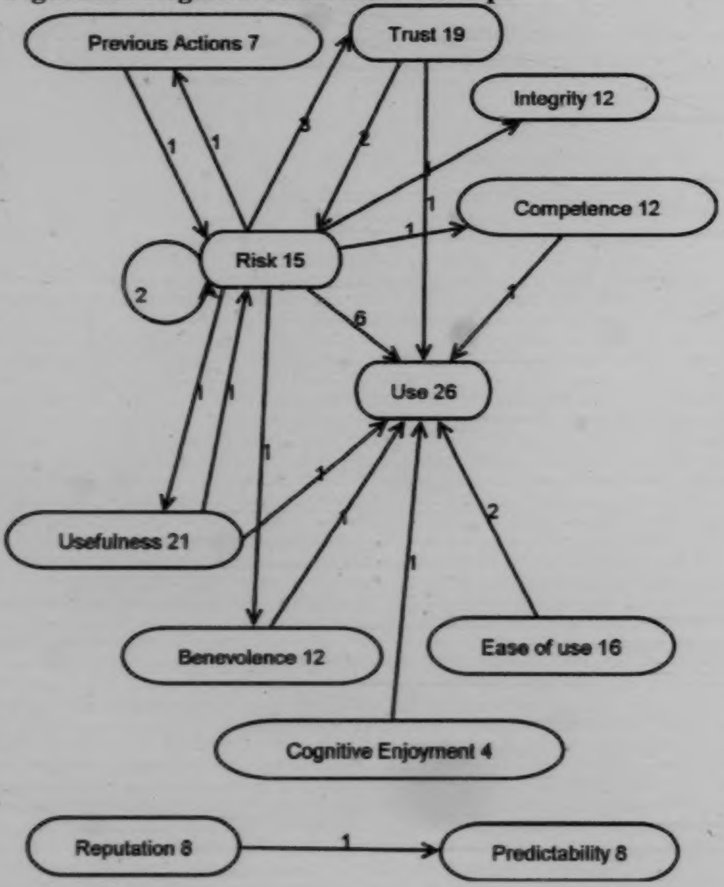
There were a total of 18 negative effect relationships found. All relationships of this type had low weightings with most of them having a weighting of 1. Table 13 shows the factors' values as antecedents and consequences from negative relationships. Most of the values are insignificant. The factors of interest are Risk as the strongest antecedent and Use as the strongest consequence.

Table 13: Factors as Antecedents and Consequences for Negative Relationships

Factor	Weights Out	Weights In
Benevolence	1	1
Cognitive Enjoyment	1	0
Competence	1	1
Ease of use	2	0
Integrity	0	1
Predictability	0	1
Previous Actions	1	1
Reputation	1	0
Risk	15	5
Trust	3	3
Use	0	13
Usefulness	2	1

Figure 20 shows the model derived from using the negative relationships.

Figure 20: Negative Effect Relationships


Previous Actions 7
Trust 19
Integrity 12
Competence 12
Risk 15
Use 26
Usefulness 21
Benevolence 12
Ease of use 16
Cognitive Enjoyment 4
Reputation 8
Predictability 8
1
1
3
2
1
1
1
2
6
1
1
1
1
1
1
2
1
1

It may seem counter intuitive at first that factors like Benevolence or Ease of use can have a negative effect on Use, however this is due to the way that the data was coded. When items were coded into a category, both negative and positive items relating to a category were coded there. For example, a "complex, busy layout" would be coded under Ease of use, however it would negatively effect Use. A user would be more willing to use a site that they find to be fun, simple, and helpful than a website that they find boring, complicated, and unhelpful. Both positive and negative aspects of a factor will be examined in more detail in the next section.

That factors that do not have a negative relationship associated with them are Ability, Attitude, Demographics, Innovativeness, Other and Social Pressures. Four of these factors are considered attributes of the user (Ability, Attitude, Demographics, Innovativeness). The fact that none of these factors negatively effect Use (or any other factor) is more likely a deficiency in current research then a reflection of reality. Intuitively it makes sense to say that a user who is computer illiterate (Ability) would be less likely to make online purchases or a user who is very slow to trust (Attitude) would also be slow to give their personal information online. Current research is more likely to examine what would cause a user to interact with a system as opposed to what would cause a user to not interact with a system.

2.3.4.2 Category Analysis

Table 14 shows the count values of all factors. Usefulness and Ease of Use with rankings 2 and 4 respectively are the core part of the Technology Acceptance Model (TAM) [29]. TAM is widely used in research into Internet, e-commerce, and computer use so it is not a surprise to see these factors ranked so high in this study. Trust and Risk were also very highly ranked at number 3 and number 5. Lack of trust is considered by many researchers to be the main barrier to e-commerce [23, 164]. The concept of risk is highly related to the concept of trust as trust becomes necessary in a situation where risk is present [165]. Many of the primary reports used in this study broke trust into the three sub-components integrity, benevolence, and competence [18, 19, 37, 43, 59, 146]. These sub-components tie for a ranking of number 6 along with Attitude.

One factor that has a surprisingly low ranking is Reputation, which is tied for 10th place with Predictability. Although reputation is not found in research as prevalently as other factors, it is a common method for building trust in industry. Many websites rely on user ratings of content, products, and other users in order to influence use of the site. Websites such as http://www.futureshop.ca, http://www.ebay.com, and http://slashdot.org all use this method.

Table 14: Ranking of Factors

Category	Count
Use	26
Usefulness	21
Trust	19
Ease of Use	16
Risk	14
Integrity	12
Benevolence	12
Attitude	12
Competence	12
Reputation	8
Predictability	8
Previous Actions	7
Ability	6
Social Pressures	5
Cognitive Enjoyment	4
Demographics	2
Innovativeness	2
Other	2

The factor counts are important in determining the significance and use of each factor but are not the only measure that should be looked at. The sum of weights from all relationships into and out of a node also shows a great deal about each factor. The sum of weights from relationships into a node shows how much that factor acts as a consequence while the sum of weights from relationships out of a node shows how much that factor acts as an antecedent. It is important to know which factors are strong antecedents as these are the factors that should be first integrated into a prospective website or e-commerce site. Both positive and negative relationships are included in these values. Although these are two different types of relationships, it makes sense to include them both because we are examining the overall effect a factor has on other factors, or an overall effect other factors have on a specific factor. We are not examining a specific relationship. Table 15 and Table 16 show the sum of weights out and sum of weight in respectively.

Table 15: Factors as Antecedents

Factor	Sum of Weights Out
Usefulness	43
Risk	36
Ease of use	33
Competence	22
Reputation	21
Integrity	21
Benevolence	17
Attitude	17
Trust	15
Ability	13
Predictability	12
Cognitive Enjoyment	9
Previous Actions	7
Use	6
Social Pressures	5
Other	2
Innovativeness	1
Demographics	1

Table 16: Factors as Consequences

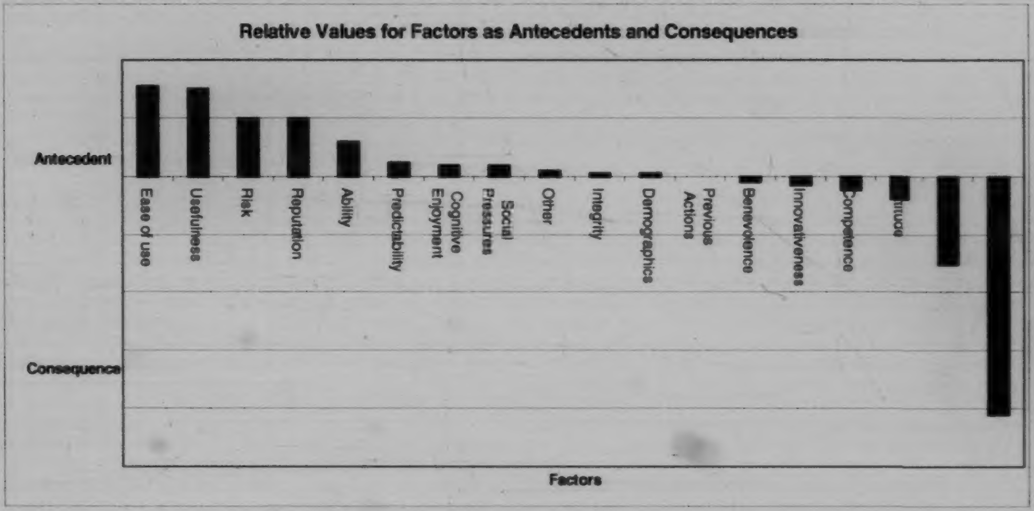
Factor	Sum of Weights In
Use	88
Trust	45

Competence	27
Attitude	25
Integrity	20
Benevolence	19
Risk	16
Usefulness	13
Predictability	7
Previous Actions	7
Cognitive Enjoyment	5
Innovativeness	4
Ease of use	2
Reputation	1
Ability	1
Social Pressures	1
Other	0
Demographics	0

For the most part factors that are rated high as antecedents are also rated high in category counts (see Table 14). For example, Usefulness is rated as the highest antecedents and is the second highest in category counts. There are a few notable exceptions however. Although Trust and Use are rated high in the category counts, they are both fairly low as antecedents. However, Trust and Use are rated as the top 2 Consequences. In order to better see how factors relate to each other as antecedents and consequences relative values must be examined.

Figure 21 shows how each factor rates as an antecedent or consequence. The relative values are determined by taking the difference of the absolute antecedent and consequence values. This graphs shows a few interesting points. Although reputation is rated as the 5th highest antecedent with absolute values, it ties for the 3rd highest in relative values with Risk. Reputation acts almost exclusively as an antecedent with a value of one for consequence. This indicates that reputation cannot be gained by increasing other factors on a website. However, having a high reputation would have a strong positive effect on other factors in the website. Another interesting point is the relative values of Ability and Attitude. Although both of these factors are characteristics of the user and not the website, Attitude acts more predominantly as a consequence while Ability is almost exclusively an antecedent. This indicate that there is very little a website can do to positively effect a user's ability to use a computer or the Internet however a user's attitude can be effected by various attributes of the system they are using.

Figure 21: Relative Values for Factors as Antecedents and Consequences



Each factor will now be examined in detail as a consequence to better understand how and by which other factors it is effected. It is important to examine both negative and positive effects on a factor. For example, if a website maintainer wanted to increase trust in the site, it would be important to look at the factors that increase trust so that they can be implemented and factors that decrease trust so that they can be minimized. In the following tables, all negative relationships will be shown by the weight having a negative sign in front of it.

The highest rated consequence is Use. Table 17 shows each factor that directly effects Use and the weight of that relationship. Use is the most important consequence to examine because ultimately, use of a website or e-commerce store is the end goal. It is not a surprise that Usefulness has such a large effect on Use, as Usefulness is the second highest rated category (category counts) and the highest rated antecedent. What is of more interest is that Attitude has the second largest effect on Use. This means that a user's feelings towards a website have a large effect on their use of the website. User feelings or attitude can be difficult to predict or effect. However this study has indicated that Attitude is predominately a consequence therefore there are factors that can positively effect a user's feelings toward a website. This will be examined in more detail below. Some of the strongest effects on Use come from factors that are predominantly consequences (Attitude, Trust, Competence) or factors that are weak antecedents (Integrity). It is therefore necessary to examine some of these factors in more detail in order to increase Use. Risk is by far the largest deterrent to website use. Appearing in half of the reports in this study, Risk is common concept in Internet adoption and e-commerce research. With the recent problems with online and credit card fraud, Risk is an important factor to examine when effects on Use.

Table 17: Effects on Use

Factor	Weight
Usefulness	12
Attitude	8
Trust	6
Integrity	6

Ease of use	5
Competence	5
Use	4
Social Pressures	4
Previous Actions	4
Benevolence	4
Risk	3
Reputation	3
Cognitive Enjoyment	3
Predictability	2
Other	2
Ability	2
Innovativeness	1
Demographics	1
Risk	-6
Ease of use	-2
Benevolence	-1
Cognitive Enjoyment	-1
Competence	-1
Trust	-1
Usefulness	-1

Trust is the next highest rated consequence. Table 18 shows the factors that effect Trust and the weights of those relationships. Again, Usefulness has the strongest effect on Trust. It may seem strange that Risk has such a strong positive effect on Trust. This is due to the way that Risk was coded. All factors were coded in a way that both positive and negative aspects of the factor were included however it showed most prominently in Risk. For example, poor security for a payment mechanism would increase perceived risk and therefore be coded Risk. High security on a payment mechanism would decrease perceived risk, thereby being coded as Risk and having a positive effect on Trust. Risk is also the only factor to negatively effect Trust. Reputation ties with Usefulness and Risk for having the strongest effect on Trust. As discussed above, reputation systems are common on websites and e-commerce sites and help to increase trust and site use.

Table 18: Effects on Trust

Factor	Weight
Usefulness	6
Risk	6
Reputation	6
Integrity	5
Ease of use	5
Benevolence	4
Competence	3
Predictability	2
Attitude	2
Use	1
Trust	1
Previous Actions	1
Risk	-3

Table 19 shows that factors that effect Competence and the weight of those relationships. The 5 factors that have the strongest effect on Trust (Usefulness, Risk, Reputation, Integrity and Ease of use) also have the strongest effect on Competence, while the only factor that negatively effects Trust (Risk) is also the only factor that negatively effects Competence. This is to be expected because, as mentioned earlier, Competence is often seen as a component of Trust [7].

Table 19: Effects on Competence

Factor	Weight
Usefulness	4
Risk	3
Reputation	3
Integrity	3
Ease of use	3
Competence	3
Benevolence	2
Use	1
Previous Actions	1
Predictability	1

Attitude	1
Ability	1
Risk	-1

Attitude is the next highest rated consequence. The factors that effect Attitude and the weights of those relationships are shown in Table 20. Ease of use has the largest effect on Attitude. This may indicate that users become easily frustrated if they have trouble using a website. Research suggests that users spend a lot of their time at a computer being frustrated [166]. Because of Attitude's large effect on Use, it is important for website designers to minimize user frustration. No factors were found to negatively effect Attitude.

Table 20: Effects on Attitude

Factor	Weight
Ease of use	5
Trust	2
Predictability	2
Competence	2
Benevolence	2
Social Pressures	1
Risk	1
Integrity	1
Cognitive Enjoyment	1
Attitude	1
Ability	1

Table 21 shows the factors that effect Integrity and the weights of those relationships. A similar trend is shown here as was shown with Competence. The factors that have a strong positive effect on Integrity are the same as the factors that strongly effect Trust and Competence. Risk is the only factor that negatively effects Integrity, which is also the same as for Trust and Competence. This supports the notion that Integrity is a sub-component of Trust [7].

Table 21: Effects on Integrity

Factor	Weight
Usefulness	4
Risk	3
Reputation	2
Integrity	2
Ease of use	2
Competence	2
Predictability	1
Benevolence	1
Attitude	1
Ability	1
Risk	-1

Table 22 shows the effects on Benevolence from various factors and the weights of those relationships. Again, Benevolence shows the same trend for factors that positively and negatively effect it as does Integrity, Competence, and Trust. Benevolence is one of the factors that are commonly treated as a sub-component of Trust in literature [7]. Of the 28 reports included in this study, 6 of them grouped Integrity, Competence, and Benevolence as sub-components of Trust [18, 19, 37, 43, 59, 146].

Table 22: Effects on Benevolence

Factor	Weight
Usefulness	3
Risk	3
Reputation	2
Integrity	2
Ease of use	2
Competence	2
Predictability	1
Benevolence	1
Attitude	1

Ability	1
Risk	-1

Risk is the next highest consequence. Table 23 shows the factors that effect Risk and the weights of these relationships. There are lots of small effects on Risk however no factors stand out as having a significant impact. This may be due to the fact that Risk is rated much higher as an antecedent then as a consequence.

Table 23: Effects on Risk

From Factor	Weight
Usefulness	2
Risk	2
Ability	2
Integrity	1
Competence	1
Cognitive Enjoyment	1
Benevolence	1
Attitude	1
Trust	-2
Previous Actions	-1
Risk	-1
Usefulness	-1

Table 24 shows the factors that effect Usefulness and the weights of those relationships. Ease of use has by far the strongest effect on Usefulness. This relationship is predicted by the Technology Acceptance Model (TAM) [167], which is widely used in this area of research. TAM was used in the development of models for 7 out of the 28 reports used in this study [18, 22, 31, 32, 35, 36, 40]. Usefulness was found to be a very strong antecedent in this study (see Table 15).

Table 24: Effects on Usefulness

Factor	Weight

Ease of use	6
Cognitive Enjoyment	2
Usefulness	1
Trust	1
Predictability	1
Ability	1
Risk	-1

The remaining weights for all relationships have values of 1 or 2 (see Table 29). These factors work overwhelmingly as antecedents as opposed to consequences and so they're little of interest to us when examining the effects that other factors have on them.

Table 29: Remaining Effect Relationships

From Factor	To Factor	Weight
Reputation	Predictability	2
Usefulness	Predictability	1
Predictability	Predictability	1
Ease of use	Predictability	1
Competence	Predictability	1
Reputation	Predictability	-1
Usefulness	Previous Actions	1
Reputation	Previous Actions	1
Predictability	Previous Actions	1
Ease of use	Previous Actions	1
Competence	Previous Actions	1
Ability	Previous Actions	1
Risk	Previous Actions	-1
Ability	Cognitive Enjoyment	2
Usefulness	Cognitive Enjoyment	1
Cognitive Enjoyment	Cognitive Enjoyment	1
Attitude	Cognitive Enjoyment	1
Integrity	Innovativeness	1
Competence	Innovativeness	1
Benevolence	Innovativeness	1
Attitude	Innovativeness	1
Trust	Ease of use	1
Ease of use	Ease of use	1
Reputation	Reputation	1
Ability	Ability	1
Trust	Social Pressure	1

2.4 Conclusion

This study started with the research question "What are the factors that influence a subject's decision to use an online resource and in what way do those factors interact?" Through the process of a meta-study examining 28 primary reports, a model was developed to describe a subject's decision to use an online resource and is representative of the current state of research in this field.

A total of 18 distinct factors and 165 distinct relationships were found. The relationship included positive and negative correlations as well as positive and negative effects. Because of the complexity of the data found, an exploratory analysis was performed on the model with several subsets of data. This involved examining each type of relationship independently, removing low ranking factors and relationships, and examining the model from a system view which involved removing factors that were attributes of the user and could not be implemented in a system. The analysis of the model was followed by a detailed analysis of each factor and the effects on it from other factors in the system.

The first sub views of the model that were looked at in the exploratory analysis were created by removing low ranking factors and relationships. Several views were examined by choosing several different cutoff points for both factors and relationships. This analysis was performed in an effort to uncover any trends that may be overlooked when examining the model as a whole. This analysis uncovered several things. It was found that Attitude was indirectly a strong antecedent. This means that other factors have a strong influence on the model through Attitude. It was also found that Trust is closely related to Integrity, Benevolence, and Competence. The later three factors have a strong influence on the model through Trust.

The next sub view of the model that was examined was a system view. The system view was created by removing all factors that could not be built into a system such as user demographics or a user's predisposition to trust. This view was important to examine because it looks as the model that would be relevant when building an online system. The system view shows that Usefulness, Ease of Use, and Risk have the largest impact as antecedents in the system and are all factors that can be influenced by website creators and maintainers.

Throughout this exploratory analysis Use and Trust were found to be the most prominent consequences while Usefulness and Ease of use were found to be the most prominent antecedents. The only deviation from this was in the examination of the negative effect relationships where Risk was the most prominent antecedent with Use being the most prominent consequence. This suggests that the TAM model with Trust and Risk added in would make a good approximation of the adoption of websites and online services.

The exploratory analysis was followed by a detailed analysis of the effects on each factor. This gave a more detailed understanding of each factor and the interactions between the factors. The analysis of each factor gave several interesting results. It was found that Integrity, Benevolence, and Competence are all highly correlated with Trust in terms of the types and strengths of effects on them. This reinforces the notion that these three factors are actually subsets of Trust. Examining Trust is terms of these three subcomponents can aid web designers in developing usable websites and Internet services. Trust is a very abstract concept and therefore difficult to build into a system.

Integrity, Benevolence, and Competence are concepts that are easier to grasp and easier to develop. Usefulness, as the highest rated antecedent, has a large effect on most other factors. It is of interest to note that Usefulness has no direct effect on Attitude, which has the second largest effect on Use. Because Usefulness has a strong effect on most other factors, it has a large indirect effect on Attitude. This suggests that making a website or online service useful to the users of the system is the single most important factor in promoting the use and adoption of that system. Having a website or online service that is useful may out weight many short comings of the system for users.

The end goal of this research would be to have a checklist of attributes that could be added to or removed from a website to increase or decrease a specific factor. Examples may be to add user reviews of content to increase Reputation, or implement secure payment measures to decrease Risk. Several steps would have to be undertaken in order to achieve this goal. The model would have to be empirically validated through user surveys. Although all the research the model is based on is empirical, the results of that research cannot be applied directly as it is based on a small subset of the factors contained within the complete model. A combinations of literature reviews, user surveys, and surveys of website practices, would have to be performed in order to determine a checklist of attributes for each factor. The results of this process would contribute to both academic research as well as industry.

3 Privacy Enhancing Technology Adoption

Privacy is an increasingly important issue for Internet users, especially in the world of commerce where consumers must disclose large amounts of personal information to make purchase. A number of Privacy Enhancing Technologies (PET) are currently available, including the Platform for Privacy Preferences Project (P3P)[3], privacy seals, and human-readable privacy policies, which aid consumers in protecting their privacy. In the case of P3P, adoption is a symbiotic process, as vendors must post P3P policies, and consumers must deploy a P3P agent. Thus, vendors and consumers must be persuaded that P3P is or will be widely adopted before committing to P3P deployment. In this paper we survey the current deployment of P3P within the e-commerce industry. Results from a web crawl performed in February 2005 will be presented to illustrate the current state of P3P adoption on e-commerce sites. We then examine P3P's "usefulness" as a PET in e-commerce, using Rogers' drivers of innovation adoption [30].

3.1 Privacy Enhancing Technologies

The Center For Democracy and Technology defines a PET as any piece of software, hardware, or documentation that helps a user protect their privacy on the Internet. There is a wide range of PETs currently available; however, we will only examine three that are prevalent in e-commerce settings, with a focus on P3P. For additional detail, the reader should consult [168].

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[3] http://www.w3c.org/P3P/

3.1.1 Platform for Privacy Preferences Project (P3P)

P3P is the current recommendation of the W3C for handling privacy issues during online transactions. P3P documents are based on an XML schema that allows vendors to publish their privacy policies in a machine-readable format. By using a P3P-enabled web browser, consumers are then able to determine the privacy policies of a site, and how these policies match (or conflict with) their preferences – without wading through the legal jargon of the natural-language privacy policy. The P3P XML schema defines eight top-level tags and over 40 subsidiary tags that encode crucial privacy information (see Table 26). A valid P3P policy is not required to contain all of these tags.

Table 26: Top-Level P3P XML Tags

TAG	DESCRIPTION
CATEGORY	Categories of data that are collected by a website
DATA	Specific data items collected by a website
PURPOSE	The reason(s) why data is being collected by the website
RECIPIENT	Personnel the website will permit to access collected data
ACCESS	Type of access the website provides a user to collected data concerning them
RETENTION	Period of time collected information will be kept by the website
DISPUTES	Recourses available to the user if the website does not abide by its posted privacy policy
REMEDIES	Remedies the website will offer to the user if there is a breach of the website's privacy policy

To use P3P, one deploys a P3P enabled browser or user agent. Several of these user agents currently exist. A P3P agent is implemented in Internet Explorer 6.0 (IE6) and AT&T has developed an extension for Internet Explorer called Privacy Bird[4]. Other agents include Netscape Navigator and Privacy Fox. These agents collect and analyze P3P policies, and provide varying amounts of feedback to the user. They also allow the user to customize their privacy preferences; this customizability varies greatly and may be anything from a slider bar to a set of multiple-choice questions.

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[4] http://privacybird.com/.

3.1.2 Human Readable Privacy Policies

Many websites choose to employ human readable privacy policies, and P3P requires sites to provide a human-readable policy. In 2002, the Progress and Freedom Foundation found that 83% of websites posted privacy policies [169]. Any privacy policy must meet a company's legal requirements, as these policies are legally binding in many jurisdictions. In the United States, the Federal Trade Commission enforces posted privacy policies, along with the state Attorneys General. Privacy violations are handled in accordance with the European Data Directive within the European Union and in accordance with the Personal Information Protection and Electronic Documents Act in Canada.

Human readable privacy policies can be difficult to understand, as a company's legal department writes many of them and the necessary legal terminology often makes their meaning obscure to the non-specialist. Jensen and Potts [170] state that only a small number of posted policies are understandable to the majority of Internet users, bringing into question the effectiveness of such policies. In addition, Schwaig et al [171] found that human-readable privacy policies are often "very deceptive" and do not follow the OECD Fair Information Practices standard.

3.1.3 Privacy Seals

Seals are a third party mechanism to certify that a website is secure, follows specific privacy guidelines, or is generally considered safe for consumers to use. The issuers and coverage of online seals vary greatly and most of the online seal programs are based in the United States. Two of the most popular seal programs are BBBOnline and Truste. The requirements for obtaining a BBBOnline or Truste privacy seal are very similar; a vendor must complete a self-assessment, allow a third party audit of their website, and agree to continual monitoring and a dispute resolution process.

Moores' [172] surveyed user's perceptions of privacy seals, and found that although users understood that privacy seals involved promoting online trust, they did not understand the criteria for awarding seals, nor how to recognize a genuine seal. This indicates that seals supply very little information to consumers about a vendor's information practices. Furthermore, the 2002 Progress & Freedom Foundation report [169] found that only 12% of sites were participating in a privacy seal program.

3.2 Methodology

Because of the high number of websites checked for p3p policies in this survey it was necessary to develop an automated process. To do this, various lists of websites were extracted from online sources and entered into a mySQL database. Some of these sources provided the lists for download in a database friendly format while others required a simple web crawler be built to extract the list. A perl script was then created to iterate through the website list from the mySQL database and send each url to a P3P validator for validation. The results of the validation were then placed back into the database. The P3P validator used in this survey was the W3C P3P Validator[5] tool. Because this tool is web based it was altered to run on a linux command line and store all results in a MySQL database. The W3C P3P Validator checks the well-known P3P policy location, the HTTP headers, and the link tags on the main page of the website only.

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[5] http://www.w3.org/P3P/validator.html

It was decided that it was not feasible to automate checking for human readable privacy policies and privacy seals as the links to them from a website may take a number of different forms. In order to complete this part of the survey two evaluators examined each website from the lists and recorded whether or not the site contained a human readable privacy policy or a privacy seal. The evaluators worked independently while performing the study. Any discrepancies between the results of the two evaluators were rechecked to ensure the reliability of the results. Only the main page of the websites was checked to provide consistency with the P3P survey.

3.3 Adoption of Privacy Enhancing Technologies

In February of 2005 we harvested all P3P policies from selected public rankings of popular websites, to determine current P3P adoption rates and compare these to a previous 2003 survey of P3P adoption [173]. Specifically of interest to us was the use of P3P and other PETs on e-commerce websites. The website rankings used were:

- E-Commerce: This list contains the top 300 retail e-commerce websites according to Internet Retailer[6]. These sites were ranked based on Internet sales. This list was considered the most important as it represents e-commerce vendors' approaches to privacy assurance on their websites.

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[6] http://www.internetretailer.com/top300/index.htm

- Forbes: This list contains the websites for the top 500 companies in the Forbes 2000 largest global companies ranking[7]. This list represents how the largest, often multinational, companies are providing privacy assurance on their websites.
- Ranking: This list contains the top 5000 web domains according to ranking.com[8]. These rankings are based on the number of unique visitors to a website over a six month period. This list represents how popular sites on the Internet are providing privacy assurance to their visitors.

AT&T conducted a similar survey in May 2003 [173]; this survey also included news sites, children's sites and government sites, which our survey did not address. The results of this survey are summarized in Table 27 along with our current findings for P3P adoption rates. Not all websites were accessible; Table 27 includes the number of sites per ranking that were reachable. There was a small amount of overlap between the three rankings:

- 6 sites were common between the E-Commerce and Forbes rankings
- 48 sites were shared between Ranking.com and E-Commerce
- 79 websites were common between Ranking.com and Forbes.

Table 27: P3P Adoption Rates

	E-Commerce	Forbes	Ranking	Total	AT&T 2003
Sites	299	495	4885	5553	5728
Sites with P3P	63	17	408	463	538

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[7] http://www.forbes.com/lists/

[8] http://www.ranking.com/

% Sites with P3P	21.1%	3.4%	8.4%	8.34%	9.4%

Our first observation is that there has been a minor drop in overall adoption of P3P since the 2003 survey. That survey found an overall adoption rate of 9.4%, compared with an 8.4% adoption rate for the Ranking list (which we treat as a proxy for the general Web rather than specific sectors) in our current survey. We used Fisher's two-tailed test [174] to check for statistical significance in all our results, as the variables we are testing (existence of P3P policies) are dichotomous in nature. Our threshold for significance is the traditional value of 0.05. This test indicates that the difference between the Ranking adoption rate and the AT&T results is not significant ($p<0.0657$). Next, we compared the sites collected from each of the lists in our current survey. We observed that there are major differences in P3P adoption in different sectors. By taking the Ranking list as a basis for comparison, we can see that P3P adoption in the E-Commerce list is roughly 2.5 times higher, while in the Forbes list it is roughly 2.5 times lower; these differences are statistically significant ($p<0.0001$, $p<0.0002$, respectively).

To further understand the differences between the E-commerce and Forbes sites, we measured the adoption rates of both privacy seals and human readable privacy policies. In determining if a website had a human readable privacy policy or privacy seal we examined only the homepage of a site, thereby aligning this measurement with the P3P data collection mechanism (which locates the policy for the homepage of a site). This additional data is summarized in Table 28.

Table 28: Privacy Technology Adoption Rates

	E-Commerce	Forbes
Number of Sites	299	495

Sites with human readable policy	250	322
% Sites with human readable policy	83.6%	65.1%
Sites with seals	85	14
% Sites with seals	28.4%	2.8%

We found that the difference in P3P adoption rates between the E-Commerce and Forbes lists can also be seen in the use of other PETs. The E-Commerce list has a ~1.3 times higher adoption rate of human readable privacy policies and a 10 times higher adoption rate of privacy seals; again, these differences are statistically significant ($p<0.0001$ in both cases). When this is combined with the observations from Table 27, we can infer that e-commerce sites are more likely to deploy PETs than websites belonging to large corporations outside the e-commerce sector. This may well be a reflection of the different business drivers between dedicated e-commerce and more general corporate sites.

Table 29 shows the use of both P3P and privacy seals in the E-Commerce list. It is of interest to note that although we see 21% and 28% adoption rates in the E-Commerce list for P3P and privacy seals respectively, only 6% of these sites choose to adopt both P3P and privacy seals. We found that 28% of sites from the E-Commerce list use privacy seals, irrespective of P3P adoption on the site. Fisher's test confirms that there is no statistical difference in seal adoption between P3P adopters and non-adopters ($p=1.0$). This finding raises the question of how e-commerce vendors view privacy seals and P3P: are they viewed as separate technologies, as options in a general privacy-protection strategy having different costs, or are they mostly adopted through persuasion by technology champions within an organization? Further research will be required to answer this question.

Table 29: E-Commerce Use Of P3P And Seals

	P3P Enabled	Not P3P Enabled
Sites w/o seals	45	169
Sites with seals	18	67

3.4 Discussion

Our findings suggest that e-commerce vendors deploy more PETs than general websites and large corporation websites. IBM recently performed a survey [175] of companies in order to determine the business drivers behind the adoption of PETs, which perhaps sheds light on this disparity. They found that there are several main reasons for a company to be concerned about the privacy of their customer data; these included complying with privacy legislation, the risk of brand damage (if there is a privacy breach), and the opportunity to streamline internal company processes that deal with customer data. Additionally, the cookie-blocking features of the IE6 agent may also be driving websites to adopt P3P [176]. Default settings in IE6 block third-party cookies without compact P3P policies. For e-commerce vendors, these business drivers appear to favor adoption of PETs; for other sites, these drivers may have less influence.

The question now arises, why have more e-commerce sites not adopted P3P? There appear to be significant business drivers favoring P3P adoption for e-commerce vendors. However, unlike other PETs, P3P both requires the vendor to deploy P3P, and the user to deploy a P3P user agent. We hypothesize that the P3P user agents are the weak link. To examine this possibility we will look more closely at P3P as a technological innovation, from the user's perspective. We concentrate on the user perspective rather than the vendor's because deployment of P3P policies is under the vendor's control; user adoption of P3P agents is not. However, the vendor's return on investment for deploying P3P will depend heavily on user adoption of P3P.

3.4.1 A Possible Explanatory Framework from the User's Perspective

In the following discussion, we explore a set of potential motivations for adoption of a new technology. While there is clearly no unique methodological approach to such an analysis, we propose to adopt Rogers' innovation diffusion model [30] as the basis of our discussion. This model describes the social, economic and technical factors that influence adoption of a technology. Rather than using this model to predict expected adoption, we will use it to develop a possible rationale for the numerical results of Section 3. We will compare these "adoption" characteristics with the pertinent literature on human-computer interaction, as it relates to P3P and PETs.

3.4.1.1 Relative Advantage

Relative advantage is the perceived advantage an innovation has over its predecessors. If an innovation or technology is seen to have no relative advantage over existing technologies, then the users of the existing technology will not adopt it. We contrast P3P with human-readable policies and privacy seals in this section.

P3P does have significant advantages over human-readable policies or privacy seals. Human readable privacy policies can be deceptive and difficult to understand [170], while few Internet users understand privacy seals or what a company must do to acquire them [172]. P3P covers a company's information practices in greater detail than privacy seals, and *potentially* allows a user to make an informed decision based upon detailed information. A major advantage is that P3P is automated. P3P agents can provide readable summaries of a company's privacy policy or verify a range of different privacy seals. It is also possible to detect policy elements that users find objectionable, and highlight them. Finally, only P3P can overcome IE6 cookie blocking.

3.4.1.2 Compatibility

Compatibility is the consistency of an innovation with the values, experiences, and needs of users. If a new innovation or technology is radically different from existing technologies, society will be slow to adopt it.

P3P appears to be consistent with users' values and needs. Most Internet users have some level of concern about their privacy online [17], and thus a need for assurance that their privacy is protected. However, very few Internet users have used a PET before:

- A study by Fox [177] found that only 9% of Internet users have used encryption in their e-mail, only 5% have used anonymizing software, and 56% do not know what cookies are!
- A recent study by Jensen et al [178] found that although 90% of participants claimed to understand cookies, only 14% actually possess that understanding.
- In addition, as stated above users lack an understanding of both privacy seals and human-readable privacy policies.

This suggests that P3P is not compatible with users' past experiences, as most users have no experience with any PET process or technology.

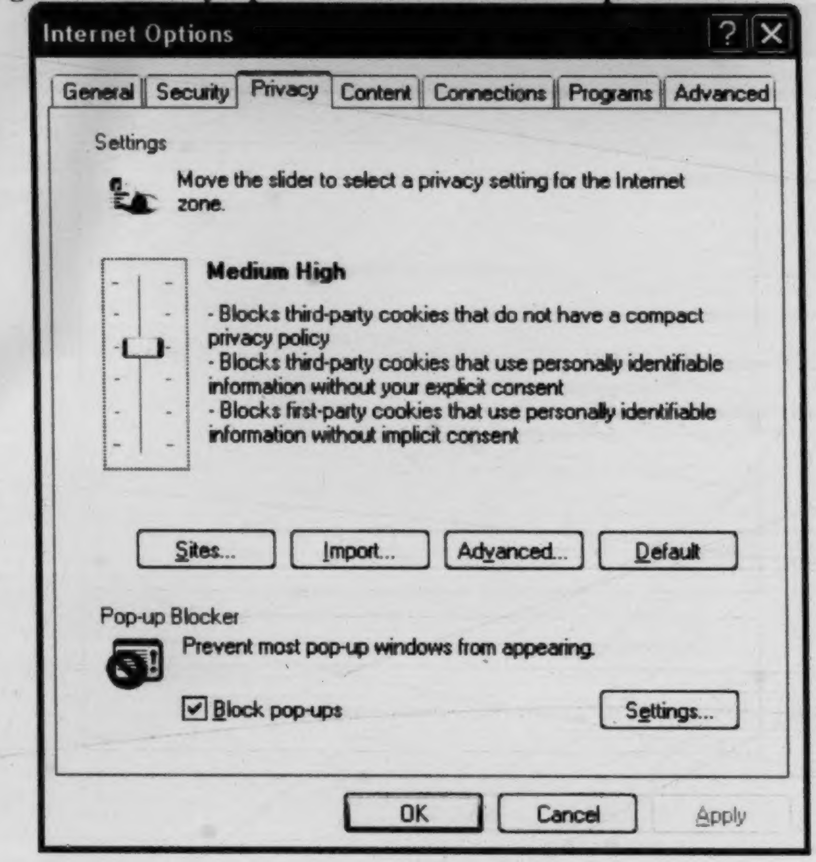
3.4.1.3 Complexity

Complexity refers to the ease of use and understanding of an innovation. Users will be slow to adopt a technology that is difficult to understand, despite any advantages it may have over its predecessors.

Cranor et al. present an extensive study of the Privacy Bird user interface in [176]. A laboratory usability study found that Privacy Bird was significantly more usable than the IE6 P3P agent. Privacy preferences can be encoded using APPEL rulesets, and compared to a policy; the results are presented as a bird icon. Significant usability problems still remain to be resolved, particularly the wording of policy summaries. Some users also find the bird icons used counterintuitive, and there is no tool to easily create APPEL rulesets [176]. Studies on earlier P3P agent prototypes are also discussed. In totality, Privacy Bird is still a complex tool.

IE6's P3P user agent checks for compact P3P policies associated with cookies and provides a summary of a site's P3P policy. The agent provides a slider bar with six possible positions (the dialog also contains settings for the pop-up blocker feature as of Windows XP SP2; see Figure 22). The slider bar only sets preferences for accepting or rejecting cookies. Considering that more than 50% of Internet users possess little understanding of cookies [178], this slider bar's utility is questionable. The "Advanced" button allows users to specify cookie behavior more precisely, while the "Sites" button permits site-specific cookie management. Considering that most users possess little understanding of cookies, this feature's utility is debatable. Netscape Navigator provides similar capabilities.

Figure 22: Privacy Options Screen in Internet Explorer 6.0



Internet Options
General
Security
Privacy
Content
Connections
Programs
Advanced
Settings
Sites...
Import...
Advanced...
Default
Pop-up Blocker
Settings...
OK
Cancel
Apply

Move the slider to select a privacy setting for the Internet zone.

Medium High

- Blocks third-party cookies that do not have a compact privacy policy
- Blocks third-party cookies that use personally identifiable information without your explicit consent
- Blocks first-party cookies that use personally identifiable information without implicit consent

Prevent most pop-up windows from appearing.

☑ Block pop-ups

Many researchers [179, 180] have pointed out that lack of appropriate feedback is a major shortcoming of automated systems, making them harder for users to operate and understand. This shortcoming is evident in P3P user agents. Internet Explorer's user agent gives virtually no feedback; cookies are either blocked or accepted based upon user settings, and no other P3P elements are implemented. AT&T's Privacy Bird gives some feedback in a traffic-light format (a green, yellow, or red bird) but ignores context; the user must then supply their own interpretation. In summation, P3P user agents are highly complex, making users less likely to adopt them.

3.4.1.4 Trialability

Trialability is the ease of experimentation with, and exploration of, an innovation. Users will be hesitant to adopt a new technology without some indication that it will be effective. Trial runs or limited experiments using the new technology are key indicators of effectiveness.

It is difficult for end users to try P3P on a limited basis. A user must make a significant commitment of time and effort in order to download and install a P3P user agent, learn how to use the agent, and set the agent up for their personal privacy preferences. As previously mentioned [17, 177], although most Internet users are concerned about their privacy, few of them do anything to protect it. There is a need for easy-to-use trial versions of P3P agents that will acclimatize users to their usage, and appropriate distribution channels.

3.4.1.5 Observability

Observability refers to the visibility of an innovation to its users. If end users cannot see the results or benefits of an innovation then the benefit of using that technology may come into question. This is especially important if the reasons behind using a technology are economic in nature.

In addition to the studies criticizing automated systems, a recent study by Jensen et al [178] showed that very few people actually understand P3P. Only 5.4% of the participants of this survey understood P3P. The authors considered this figure to be an upper bound, as the study participants were on average more educated about the Internet and privacy than the general Internet population. It thus appears that P3P is not well known among the user population (and perhaps among site administrators), indicating poor observability.

3.4.1.6 Discussion of P3P's Characteristics of Innovation

Our analysis of P3P indicates that P3P has a significant relative advantage over other PETs, and is compatible with user values and needs. However, P3P user agents are complex and poor in trialability, incompatible with user's past experiences, and P3P observability is poor. Our analysis thus indicates that P3P has definite shortcomings in four out of five of Rogers' characteristics. We urge caution in interpreting this analysis as a causal explanation for our numerical results in Section 3.3, although there is likely to be an association. Improvements to the P3P agents may well enhance the user experience, although there is no guarantee that this will translate into increased adoption rates.

3.4.2 Conclusion

P3P adoption on e-commerce websites, although higher than in many segments (generally popular sites; large corporate sites), is still relatively low. There appears to be a need for and interest in P3P; however, there are several problems that need to be overcome before it will gain widespread use. Currently available user agents are confusing to use and do not provide users with the information they need to make informed decisions. Most users are in fact unaware of P3P's existence! We suggest that P3P needs to gain greater visibility among the general Internet population, perhaps in the form of an icon placed on a website stating that the site is P3P enabled. We also believe that a more appropriate P3P user agent is needed, which will give more suitable and useful user feedback and take into consideration the context in which a user is being asked for their personal information. Additional design considerations are discussed in [176].

4 Correctness of Websites

4.1 Introduction

Fogg describes Web credibility as a combination of the perceived trustworthiness of the website and the perceived expertise of the website [181]. Web credibility is described as a major factor in enabling websites to influence users, whether by convincing users to login to the site, use information from the site, purchase goods or services from the site, or just browse the site. Fogg et al [1] have performed several surveys to determine which characteristics of a website affect a user's sense of the credibility of that site [45, 87]. These studies show that the "look and feel" of a website had a large impact on how credible users perceived the site to be. The "look and feel" of a website includes factors such as:

- The real world feel of a site (the feeling that a real person is behind the website to help customers);
- How easy the site is to use;
- The expertise of the site on its topic of choice;
- The trustworthiness of the site
- How well the site is tailored to its users;
- Whether or not the site is just about making money; and
- How amateur the site seems (broken links, errors, site unavailable).

Several other researchers have also witnessed the affect the "look and feel" of a website has on website usage:

- Stephens found that page layout, page navigation, graphics, and a "professional style" all affect the perceived trust of a website [43].
- Sillence et al found that the design of a website played a large role in whether or not people would use a site [20]; while
- Briggs et al found that a website's look and feel, easy of navigation, and number of errors or the amount of clutter affected a users initial feelings of the trustworthiness of the site [42].

This research suggests that users are more likely to trust and use well designed websites that are free of errors.

A study of organizations' website design methods found that 68% of the organization used no development techniques when building websites [182]. This should not come as a surprise as 95% of websites do not validate to W3C's HTML standards [183]. W3C is responsible for developing and maintaining standards for Hypertext Markup Languages (HTML)[9] and Cascading Style Sheets (CSS)[10] however the above research suggests that these standards are not being adhered to. Current research is working towards improving website usability. Chen and Shen [184] have developed a prototype tool for transforming non-compliant websites into HTML and CSS compliant sites. Several methods have been developed to analyze the usability of websites. Keevil [185] developed a checklist for use in measuring the usability of a website while Bauer and Scharl [186] describe an automated approach. Many researchers also point out the problems with broken links on websites [45, 87]. Weinriech and Lamersdorf [187] suggest a method for introducing extra information into links so that users can tell if they are broken or go somewhere the user does not want. Instead of warning users about broken links, Ingham et al [188] proposed a method for maintaining link integrity.

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[9] http://www.w3.org/MarkUp/

[10] http://www.w3.org/Style/CSS/

4.2 Problems with Website Evaluation

It was seen in Section 2 that a user's trust and ultimately use of a website was negatively affected by errors on the site. The goal of this study is to evaluate the technical components of a website, however problems arise when evaluating certain aspects of websites. There are many tools available for evaluating a web server. These tools examine the server's security, which software is used on the server, and whether all software used is up to date. Up to 90% of Internet attacks could have been prevented by having up to date software installed on the server [189]. If permission from the owners of the web server is given to collect this information, it would be called "ethical hacking" [189, 190]. However, examining these pieces of information about a web server without permission from the owners of the server is an ethically gray area. For this reason, the current study will not examine any server-side sources of information for the websites.

4.3 Evaluation of Website Source Code

There are many pieces of data that are transferred to the client computer when a website is visited. Ignoring AJAX-enabled or similar systems, the source code of the website

(HTML) is transferred to the client computer along with any Cascading Style Sheets (CSS) used, P3P policies, and all data presented on the site. P3P privacy policies were examined in Section 3. This study will examine the HTML source of the websites, the use of Cascading Style Sheets, and the status of links on the website.

HTML is used to publish content on the Web. It defines the structure and layout of data elements on a website. An HTML document is a text file containing tags that tell a web browser how to display the contents of the file. The W3C provides current recommendations and guidelines for the use of HTML. Following these recommendations helps insure that websites display properly in different browsers and the W3C provides a validating tool to ensure that the HTML on a website conforms to the required specifications. Below is an example of a valid HTML 4.01 Strict document:

```
<!DOCTYPE html PUBLIC “-//W3C//DTD HTML 4.01//EN” http://www.w3.org/TR/html4/strict.dtd>
<html>
<head>
<title>Example HTML 4.01 Document</title>
</head>
<body>
<p>An example of  paragraph in HTML</p>
</body>
</html>
```

Each HTML document must begin with a DOCTYPE Declaration that specifies what type of HTML is in the document. The first line in the above example specifies that the document is HTML 4.01 Strict. An up to date list of recommended Document Types is available on the W3C website[11]. The <html></html> start and end tags are the document root element. All other elements must be inside of these. The <head></head> element is used to give information about the document which is not displayed on the website. For example the <title></title> in the HTML code above will not be displayed in the browser window. Both the head element and the title element are required in a valid HTML document. The next section in the example above is the <body></body> section. This section is where the main body or content of the HTML document is placed. The body element is required in a valid HTML document and that section must not be empty. In the example the body section contains a paragraph, <p></p>, element.

---

[11] http://www.w3.org/QA/2002/04/valid-dtd-list.html

Cascading Style Sheets are used to define the look and feel of a website. CSS documents can define such things as font information, spacing, and colors. The W3C maintains specifications and recommendations for the use of CSS on websites, which helps ensure that pages display properly. The W3C also provides a validation tool for CSS documents. Below is an example of a valid CSS document:

```
body
{
background-color: black;
color: white;
{

p
{
font-family: arial;
text-align: center;
}
```

In the example given above the *body* section defines the style to be used inside the body element of the HTML document. In this case the CSS document is telling the browser to make the background color black and the text color white. The *p* section in the above example specifies the style to be used in the p element in the HTML document. In this case the CSS document is specifying that the arial font should be used and that the text should be centered on the page. In order to use this CSS document in the HTML example given above the following line would be added into the head element:

```
<link rel=”stylesheet” type=”text/css” href=”example.css”>
```

This tells the web browser to use the external style sheet example.css in the HTML document. A style sheet can also be embedded into the HTML document directly. To do this, the following would be added into the head element in the HTML document:

```
<style type=”text/css”>
body
{
background-color: black;
color: white;
{

p
{
font-family: arial;
text-align: center;
}
</style>
```

A hypertext link is used to create a link from one HTML document to another Web resource. This is the method used to navigate from one web page to another or from one website to another. Links can be simply added into any HTML document using the <a> element. The following HTML code:

```
<a href=”http://validator.w3.org/”>W3C HTML Validator</a>
<a href=”http://jigsaw.w3.org/css-validator”>W3C CSS Validator</a>
<a href=”http://validator.w3.org/checklink”>W3C Link Checker</a>
```

could be placed inside the p element in the above HTML example. This would add links to W3C’s HTML and CSS validators and link checker. All outside resources that are referenced or linked to in a HTML document are checked by the W3C Link Checker, including style sheets, images, and hypertext links.

Broken links have a negative impact on the functionality of a website and therefore a negative impact on a user's trust of that website. Four types of HTTP responses can be returned for a link. The types of responses are OK (object was successfully retrieved), Redirection (browser was redirected to a new location), Client Error (object was not found due to a fault on the client-side), and Server Error (object was not found due to a fault on the server-side).

4.4 HTML Survey

The W3C HTML Validator[12] was used to perform this survey. Because this validator has a web based interface several changes were made to the version downloaded from the source code page[13]. The first change was to make the interface command line instead of web based so that the validator could be automated. The second change was to have the validator send its output into a Mysql database instead of to the screen. The code was then tested to insure the integrity of the validation results. Only the main page of each site was tested.

The W3C HTML Validator outputs a number of warnings, fatal errors and syntax errors. Explanations for all warnings and fatal errors are given in Table 30. There are a total of 448 syntax errors of which only a few were actually found. Descriptions for these syntax errors can be found in the appendix, Section 7.1 in the Appendix.

Table 30: Warnings and Fatal Errors

Error Code	Description

---

[12] http://validator.w3.org/

[13] http://validator.w3.org/source/

FE0	Could not retrieve website
FE2	Error with character set
FE3	Error transcoding document
FE4	Error with document type declaration (no or unknown FPI and a relative SI)
FE6	Error finding encoding
W01	Character set not found but content type is text so using us-ascii
W04	No character set found, using utf-8 instead
W06	No file mode found, using SGML by default
W07	Content type not supported
W08	No document types configuration found, mode not determined
W09	Fallback FPI, no document type found
W10	Namespace found does not match document type namespace
W11	Namespace found but document type is not XML
W12	Missing namespace
W17	No character set found
W18	Character set conflict in http header and xml
W19	Character set conflict in http header and <meta> element
W20	Character set conflict in <meta> element and xml
W21	Character set is utf-8 and contains a byte order mark (BOM)

4.4.1 Previous Work

Very little research has been done to check the quality of websites on the Internet according to the above standards. Chen et al [183] performed a survey of HTML validation problems on four separate lists of websites:

- Alexa's top 10 000 websites.
- 1100 websites obtained by randomly generating IP addresses and checking on port 80 for web servers.
- by randomly generating character strings and sending them to three search engines, Google, Yahoo, and Teoma. The first 10 results were then saved into the list producing 31540 URLs.

- The final list was obtained two months later by again randomly generating IP addresses.

The survey used W3C's HTML Validation tool to validate the websites in the four lists. They found that only 5.0% of websites that were surveyed had valid HTML.

A survey of the accessibility of United Kingdom websites was performed by Beckett [191]. The survey used a list of 13312 unique websites found under the .uk domain. The HTML on the websites was validated using the NSGMLS parser. This survey found that 6.5% of websites had valid HTML and according to the report's accessibility standard only 30% of United Kingdom websites were accessible to all users.

Pollach et al [192] performed a study of the functionality and accessibility of 226 environmental websites obtained from the Google Directory. The survey used WebXACT to check the website's adherence to W3C guidelines. This study found that 4.0% of sites had valid HTML.

4.4.2 Results

The HTML Validation survey was performed on Alexa's[14] top 100,000 website list during September and October of 2006. The list is composed of the most popular 100,000 websites on the Internet as ranked by Alexa.com, based upon the geometric mean of the number of individuals visiting a site and the number of pages they access while on the site. According to Alexa.com, websites which do not belong to this list have less than a 0.00125% chance of being visited by the average Internet user [193].

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[14] http://www.alexa.com/

The geographic location of these websites was derived by determining their IP address using the Linux 'host' program; then comparing this address with a database of addresses purchased from IP2Location [194] which maps IP addresses to a particular nation. This approach is required since the country code top level domains are not reliable indicators of the actual location that websites are hosted from [195]. IP2Location claim that their accuracy is above 95% [194].

The 100,000 websites were from a total of 131 different countries. In the case of 1235 websites, the country of origin was unknown or the website could not be reached at the time of the whois query. For each country of origin the continent it resides on is known as well as the gross domestic product (GDP) at purchasing power parity (PPP) per capita and e-Readiness ranking. All continents except for Antarctica are represented in the list. GDP PPP per capita was used because it is a measure that can be easily compared between countries and is an indicator of wealth within a country, taking into consideration standard of living. The GDP PPP per capita for each country was taken from the International Monetary Fund's World Economic Outlook database[15] for 2005. The e-Readiness ranking used was a 2005 ranking of 65 countries that was put out by IBM and the Economist Intelligence Unit [196]. The ranking has a possible range of 1.00 and 10.00 however all countries were ranked between 2.00 and 8.99 in this year's survey. Although only 65 countries are ranked, these countries account for 98% of all websites in the Alexa list. The GDP PPP per capita data and the e-Readiness data are linearly related as can be seen in Figure 23. The countries of origin for websites in the Alexa top

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[15] http://www.imf.org/external/pubs/ft/weo/2005/01/data/

100,000 list as well as the continent, GDP PPP per capita, and e-Readiness index can be found in Section 7.2 in the Appendix.

Figure 23: GDP PPP versus e-Readiness

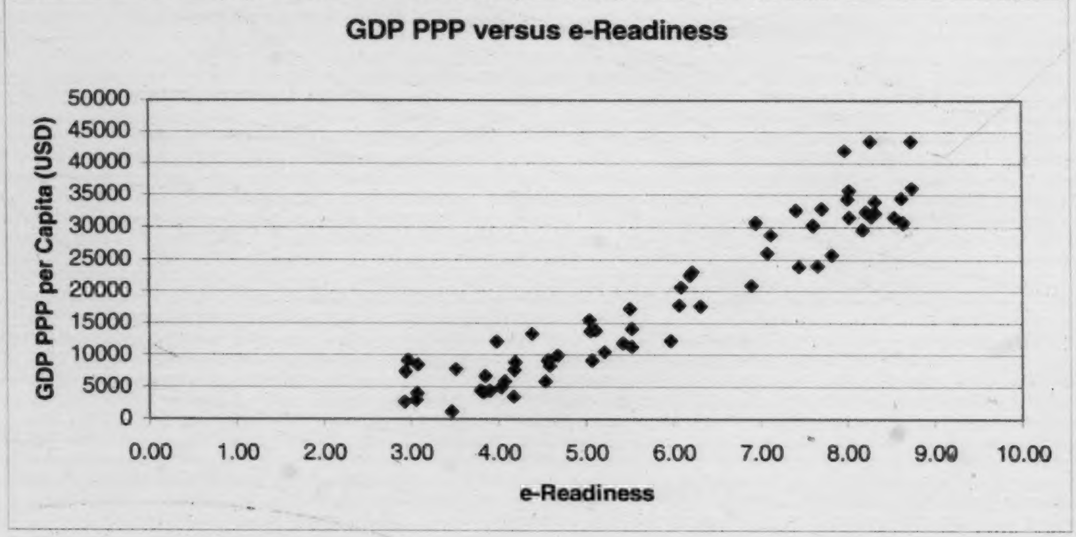

Table 31 shows the results of Spearman's correlation on website ranking, GDP PPP, and e-Readiness including confidence intervals and significance levels. Table 32 shows the R and R^2 values for these correlations. The confidence intervals for each value of Rho were calculated using the formulas given in [197]. Effect sizes were calculated from the Spearman's Rho values above using the table given in [198]. A rule for interpreting the strength of the correlations is given by Cohen where 0.1 is a weak correlation, 0.3 is a moderate correlation, and 0.5 is a strong correlation [199, 200]. No relationship was found between website ranking and GDP PPP ($p<0.747$) or between website ranking and e-Readiness ($p<0.804$). The relationship between GDP PPP and e-Readiness however was found to be strong with R being 0.969 ($p<0.001$).

Table 31: Spearman's Rho for Website Ranking, GDP PPP, and e-Readiness

		Rank	GDP PPP	e-Readiness
Rank	Rho	1.000	0.001	0.001
	p	-	0.747	0.804
	Upper	-	0.021	0.020
	p	-	0.000	0.000
	Lower	-	-0.019	-0.019
	p	-	0.000	0.000
GDP PPP	Rho		1.000	0.966
	p		-	0.000
	Upper		-	0.968
	p		-	0.000
	Lower		-	0.965
	p		-	0.000
e-Readiness	Rho			1.000
	p			-
	Upper			-
	p			-
	Lower			-
	p			-

Table 32: R and R^2 Values for Website Ranking, GDP PPP, and e-Readiness

		Rank	GDP PPP	e-Readiness
Rank	R	1.000	0.000	0.000
	Upper	-	0.016	0.016
	Lower	-	-0.016	-0.016
	R^2	1.000	0.000	0.000
	Upper	-	0.000	0.000
	Lower	-	0.000	0.000
GDP PPP	R		1.000	0.969
	Upper		-	0.972
	Lower		-	0.969
	R^2		1.000	0.939
	Upper		-	0.945
	Lower		-	0.939
e-Readiness	R			1.000
	Upper			-
	Lower			-
	R^2			1.000
	Upper			-
	Lower			-

The number of websites in this list that possessed completed valid HTML was very small, only 3020 websites out of 100,000 (3.0%), suggesting that monkeys with typewriters had a role in the creation of the Internet. The results of the surveys outlined in Section 1.4.1 are compared with the current survey results in Table 33. Because of the differences in the website samples, not all results can be directly compared to each other, however the percentage of valid sites is similar in the different surveys. However, the Alexa10k and UK surveys can be compared more closely with the results from the current survey. The Alexa10k survey can be compared with the first 10,000 results from the current survey, of which 3.3% had valid HTML. The results of the UK study which found 6.5% of United Kingdom websites had valid HTML can be compared to the 3536 websites from the United Kingdom that were checked in the current study where 8.0% of websites had valid HTML.

Table 33: Validation results from various surveys compared

Survey	Percentage Valid	Sample	Year	Reference
Current Survey	3.0%	Alexa top 100000	2006	N/A
Alexa10k	5.0%	1100 random sites & Alexa top 10000	2005	[183]
Environmental	4.0%	229 North American Environmental sites	2006	[192]
UK	6.5%	13312 sites under the .uk domain	1997	[191]

Table 34 shows the number of valid websites per country for all countries that have more than 1000 websites. All other countries represent less than 1% of all sites examined and therefore have little individual affect on the total percentage of valid websites.

Table 34: Valid Websites for Top Countries of Origin

Country	Number of Websites	Valid	Percentage Valid

United States	45212	1343	3.0%
China	17764	140	0.8%
Japan	6807	292	4.3%
United Kingdom	3536	284	8.0%
Canada	2576	91	3.5%
Germany	2434	144	5.9%
France	1858	83	4.5%
Republic Of Korea	1755	8	0.5%
Netherlands	1520	60	3.9%
Hong Kong	1437	34	2.4%
Taiwan	1340	19	1.4%
Spain	1243	83	6.7%

Fisher's Exact Test is used to determine if two sets of data are related. The null hypothesis is that the two sets of data are completely independent and this is characterized by $p < 0.05$. Table 35 shows the results of Fisher's Exact Test for valid websites compared by country.

Table 35: Fisher's Exact Test (2-tailed) for Valid Website by Country

	United States	China	Japan	United Kingdom	Canada	Germany	France	Republic Of Korea	Netherlands	Hong Kong	Taiwan	Spain
United States	1.000	0.000	0.000	0.000	0.109	0.000	0.001	0.000	0.032	0.205	0.000	0.000
China		1.000	0.000	0.000	0.000	0.000	0.000	0.148	0.000	0.000	0.027	0.000
Japan			1.000	0.000	0.102	0.001	0.748	0.000	0.622	0.000	0.000	0.000
United Kingdom				1.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.137
Canada					1.000	0.000	0.117	0.000	0.494	0.046	0.000	0.000
Germany						1.000	0.039	0.000	0.006	0.000	0.000	0.385

France							1.000	0.000	0.492	0.001	0.000	0.009
Republic Of Korea								1.000	0.000	0.000	0.006	0.000
Netherlands									1.000	0.016	0.000	0.001
Hong Kong										1.000	0.072	0.000
Taiwan											1.000	0.000
Spain												1.000

There are large differences in the percentage of valid sites in each country ranging from 8.0% in the United Kingdom to 0.5% in the Republic of Korea. This difference appears to be associated with continental location, with Asian countries having the lowest percentage of valid sites and Europe having the highest percentage of valid sites. Table 36 shows the percentage of valid sites for each continent. Africa and Asia have the lowest percentage of valid sites, Europe and Oceania the highest percentage valid, and the Americas are mid-range. The websites in the Unknown category are dominated (987 sites) by sites that were unreachable when the whois database was queried to find their country of origin. This explains the low percentage of valid websites in this category.

Table 36: Valid Websites by Continent

Continent	Number of Websites	Valid	Percentage Valid
Africa	227	1	0.4%
Asia	31895	538	1.7%
Europe	16617	939	5.7%
North America	48240	1445	3.0%
Oceania	900	59	6.6%
South America	886	27	3.0%
Unknown	1235	11	0.9%

Table 37 shows the results of Fisher's exact test for the percentage of valid websites in each continent. Most of the categories have significantly different percentages of websites with valid HTML ($p<0.05$), however there are a few exceptions. The differences between Africa and Asia ($p<0.193$) as well as Africa and the Unknown ($p<0.704$) category are not statistically significant. The difference between Oceania and Europe ($p<0.267$) is not statistically significant as well as the difference between North and South America ($p<0.921$). The differences between all other categories are statistically significant.

Table 37: Fisher's Exact Test (2-tail) for Valid Websites by Continent

	Africa	Asia	Europe	North America	Oceania	South America	Unknown
Africa	1.000	0.193	0.000	0.017	0.000	0.029	0.704
Asia		1.000	0.000	0.000	0.000	0.005	0.030
Europe			1.000	0.000	0.267	0.000	0.000
North America				1.000	0.000	0.921	0.000
Oceania					1.000	0.001	0.000
South America						1.000	0.000
Unknown							1.000

The differences in percentage of websites that are valid between countries and continents may better be explained by examining GDP PPP per capita. Table 38 shows the percentage of valid websites per category of GDP. The Unknown category consists of websites for which the country was not known as well as websites from countries that are not members of the International Monetary Fund. A trend can be seen where the percentage of valid websites increase as the GDP increases. The exception to this trend is GDP greater than $40000 USD. This category is dominated by the United States, which makes up 99% of these sites. Removing the United States from this category would give a total of 385 websites remaining of which 24 (6.2%) are valid.

Table 38: Valid Websites by GDP PPP per Capita (USD)

GDP (PPP) per Capita (USD)	Number of Websites	Valid	Percentage Valid
<10000	20557	192	0.9%
>10000	2547	57	2.2%
>20000	6230	190	3.0%
>30000	23687	1202	5.1%
>40000	45597	1367	3.0%
Unknown	1382	12	0.9%

Table 39 shows the results of Fisher's Exact Test for valid websites in each GDP PPP category. As can be seen below, most of the differences found were statistically significant (p<0.05). The exceptions were between the Unknown category and the GDP PPP category of less than $10000 USD (p<1.000) and between GDP PPP less than $40000 and less than $20000 (p<0.812). The last two categories mentioned are dominated by websites from the United States and China respectively.

Table 39: Fisher's Exact Test (2-tailed) for Valid Websites by GDP PPP per Capita

	<10000	>10000	>20000	>30000	>40000	Unknown
<10000	1.000	0.000	0.000	0.000	0.000	1.000
>10000		1.000	0.039	0.000	0.026	0.001
>20000			1.000	0.000	0.812	0.000
>30000				1.000	0.000	0.000
>40000					1.000	0.000
Unknown						1.000

Table 40 shows the number of valid websites as well as the percentage of valid websites for each e-Readiness category. A similar trend is seen here as was seen with the GDP data. The percentage of valid websites increases as the e-Readiness score increases with the exception of e-Readiness scores of over 7.00. This is to be expected as GDP PPP and e-Readiness are linearly related. Sites from the United States, which corresponds to the GDP PPP category of over $40000 USD, dominate the websites in the e-Readiness category of 8.xx and have a lower percentage of valid sites. However websites in the e-Readiness category of 7.xx deviate from this trend. This category also has a lower percentage of valid sites however is does not correspond to the GDP PPP data.

Table 40: Valid Websites by e-Readiness Category

e-Readiness	Number of Websites	Valid	Percentage Valid
2.xx	18	0	0.0%
3.xx	18977	150	0.8%
4.xx	1801	38	2.1%
5.xx	1560	41	2.6%
6.xx	1670	98	5.9%
7.xx	14147	524	3.7%
8.xx	59791	2137	3.6%
Unknown	2036	32	1.6%

Table 41 shows the results of Fisher's Exact Test for valid websites in each e-Readiness category. Most of the differences in the results were found to be statistically significant. The exceptions are between 2.xx and all other categories, between 4.xx and 5.xx, 4.xx and the Unknown category, and finally between 7.xx and 8.xx.

Table 41: Fisher's Exact Test (2-tailed) for Valid Websites by e-Readiness

	2.xx	3.xx	4.xx	5.xx	6.xx	7.xx	8.xx	Unknown
2.xx	1.000	1.000	1.000	1.000	0.620	1.000	1.000	1.000
3.xx		1.000	0.000	0.000	0.000	0.000	0.000	0.001
4.xx			1.000	0.361	0.000	0.000	0.001	0.228
5.xx				1.000	0.000	0.031	0.044	0.031
6.xx					1.000	0.000	0.000	0.000

7.xx						1.000	0.452	0.000
8.xx							1.000	0.000
Unknown								1.000

The graph in Figure 24 shows the number of valid websites (per 1000) versus ranking of the sites. This graph shows a very slight downward trend in the number of valid sites. It would seem reasonable expect to see a decrease in the quality of websites as the ranking decreases. Higher ranked websites would be expected to be of a higher quality.

Figure 24: Number of Valid Sites per 1000 by Ranking

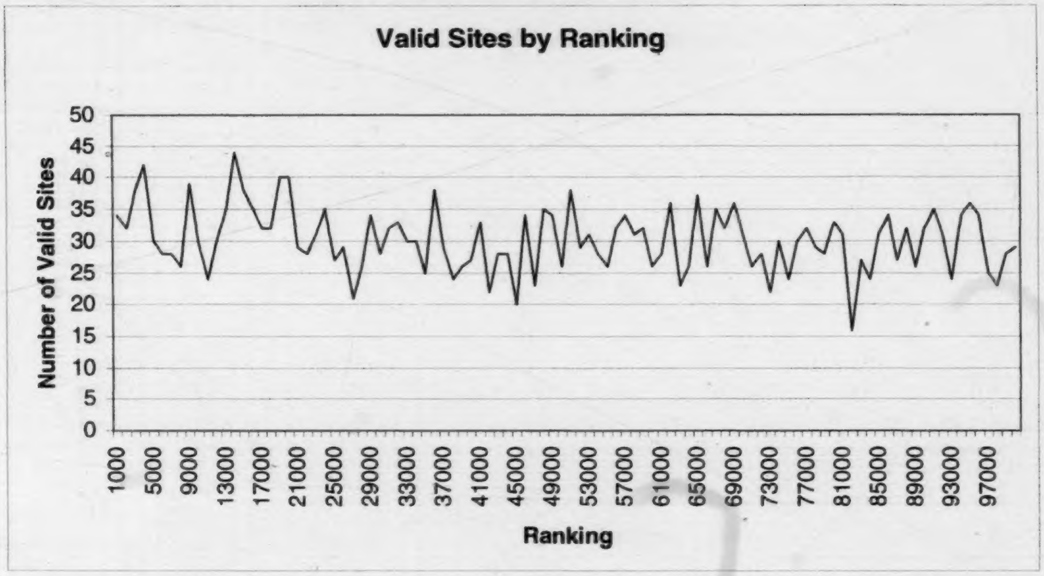

Table 42 shows the results of Spearman's correlation between websites with valid HTML and website ranking. Although the relationship is statistically significant (p<0.05), the value of R is so low that the results are negligible.

Table 42: Spearman's Rho, R, and R^2 for Valid Websites and Website Ranking

Rho	-0.007	R	0.000
p	0.025	Upper	0.016
Upper	0.013	Lower	-0.031
p	0.000	R^2	0.000
Lower	-0.027	Upper	0.000
p	0.000	Lower	0.001

A document type declaration specifies the version of HTML that the given document adheres to. This survey found 14 different document types in use. These document types are shown in Table 43 along with the number of websites that used each one. XHTML 1.0 (Transitional, Strict, and Frameset) and HTML 4.01 (Transitional, Strict, and Frameset) are the most widely used versions of HTML accounting for 71.2% of all websites. XHTML 1.1 and XHTML Basic 1.0 are part of the modularization of XHTML 1.0 and account for only 0.4% of websites. ISO HTML is based on a subset of HTML 4 standardized by ISO/IEC and is much more rigorous. Only one website used this version of HTML. HTML 4.0 Transitional, HTML 3.2 and HTML 2.0 are both previous versions of HTML developed by W3C and are not current recommendations. Websites that use these versions of HTML should be updated to a current version. HTML 4.0 Transitional, HTML 3.2 and HTML 2.0 account for 6.2% of all websites.

Table 43: Document Types Found

Document Type	Websites	Percentage
XHTML 1.0 Transitional	51163	51.2%
No Doctype	22043	22.0%
HTML 4.01 Transitional	17557	17.6%
HTML 4.0 Transitional	5885	5.9%
XHTML 1.0 Strict	1467	1.5%
HTML 4.01 Strict	511	0.5%
HTML 4.01 Frameset	399	0.4%
XHTML 1.1	379	0.4%
HTML 3.2	351	0.4%
XHTML 1.0 Frameset	101	0.1%
HTML 4.0 Strict	87	0.1%
HTML 4.0 Frameset	49	0.0%
HTML 2.0	12	0.0%
XHTML Basic 1.0	4	0.0%
ISO/IEC 15445:2000 ("ISO HTML")	1	0.0%

Table 44 shows the percentage of each document type in each country. Only countries with more than 1% of the total websites are included here, all other countries are grouped in the Other category. Also all document types that account for less than 1% are grouped into the Other document type category. XHTML 1.0 Transitional is the most widely used document type followed by HTML 4.01 Transitional. An alarming percentage of websites in all countries did not have a document type declaration with China and Korea having the largest percentage of websites with no document type. These differences will be examined in more detail in the by continent analysis.

Table 44: Percentage of Document Types in Each Country

Country	HTML 4.0 Transitional	HTML 4.01 Transitional	XHTML 1.0 Strict	XHTML 1.0 Transitional	Other	No Doctype
United States	6.7%	18.5%	1.6%	54.8%	1.9%	16.6%
China	3.8%	7.8%	0.2%	47.4%	0.5%	40.2%
Japan	2.8%	36.4%	1.0%	35.4%	2.4%	21.9%
United Kingdom	7.7%	22.4%	4.7%	48.3%	2.9%	14.1%
Canada	6.1%	19.8%	1.3%	52.8%	2.4%	17.7%
Germany	8.3%	23.7%	2.4%	45.1%	3.6%	17.0%
France	4.6%	21.2%	4.1%	52.0%	2.7%	15.3%
Republic Of Korea	2.3%	6.8%	0.2%	60.9%	1.4%	28.4%
Netherlands	5.3%	17.7%	3.2%	54.5%	3.6%	15.7%
Hong Kong	4.5%	13.4%	0.2%	60.0%	1.7%	20.3%
Taiwan	3.4%	12.7%	0.2%	62.9%	2.3%	18.5%
Spain	5.1%	15.6%	2.0%	53.3%	3.8%	20.2%
Other	7.7%	16.9%	1.9%	49.4%	2.4%	21.8%

Table 45 shows the percentage of each document type in each continent. All document types that accounted for less then 1% of the total number of websites were grouped into an Other category for brevity. There are several points of interest when examining this data by continent. Africa has a considerably larger percentage of HTML 4.0 Transitional, which is an older version of HTML, than the other continents. This may indicate that these websites are not kept as up to date as websites on from other continents. Asia has a large percentage (32.0%) of websites where no document type was found. This corresponds to a very low rate of valid websites in Asia (1.7%). If a document type cannot be found for a website, that website cannot be validated. The Unknown category also had a very high number of websites without document types. Most of the websites in this category were unreachable when querying the whois database for the country of origin.

Table 45: Percentage of Document Types in Each Continent

	Africa	Asia	Europe	North America	Oceania	South America	Unknown
HTML 4.0 Transitional	12.3%	4.0%	7.5%	6.7%	7.7%	3.5%	1.5%
HTML 4.01 Transitional	10.6%	14.8%	20.9%	18.6%	20.1%	15.7%	6.4%
XHTML 1.0 Strict	0.9%	0.4%	3.3%	1.5%	2.7%	1.2%	0.1%
XHTML 1.0 Transitional	54.6%	47.7%	49.8%	54.7%	53.8%	56.7%	16.7%
Other	1.3%	1.2%	3.2%	1.9%	2.0%	2.7%	0.2%
No Doctype	20.3%	32.0%	15.3%	16.6%	13.8%	20.2%	75.2%

The percentage of each document type in each category of GDP PPP per capita is shown in Table 46. Nations with a GDP PPP per capita of less than $10000 USD have 37.5% of websites without a document type, which is almost twice any other category. Most of the countries in this category are from Africa, Asia, or South America. Table 45 shows that these three continents have the highest percentage of websites with no document type. This suggests that websites from less developed countries are more likely to not specify a document type.

Table 46: Percentage of Document Types in Each GDP PPP per capita (USD) Category

	<10000	>10000	>20000	>30000	>40000	Unknown
HTML 4.0 Transitional	4.2%	8.1%	5.9%	5.7%	6.8%	1.6%
HTML 4.01 Transitional	8.7%	16.5%	12.8%	25.2%	18.6%	7.7%
XHTML 1.0 Strict	0.3%	1.4%	1.2%	2.4%	1.6%	0.1%
XHTML 1.0 Transitional	48.6%	56.4%	57.8%	46.2%	54.6%	21.7%
Other	0.7%	2.4%	2.4%	2.8%	1.9%	0.4%
No Document Type	37.5%	15.2%	19.9%	17.7%	16.6%	68.3%

Table 47 shows the percentage of each document type in each e-Readiness category. There is no clear relationship between the e-Readiness data and GDP PPP data. The GDP PPP category of less then $10000 USD and the e-Readiness category of 3.xx are both dominated by Chinese websites and these categories have similar values. Also the GDP PPP category of greater than $40000 and the e-Readiness category of 8.xx are both dominated by United States websites and these categories also have similar values.

Table 47: Percentage of Document Types in Each e-Readiness Category

	2.xx	3.xx	4.xx	5.xx	6.xx	7.xx	8.xx	Unknown
HTML 4.0 Transitional	5.6%	4.1%	7.1%	6.4%	9.4%	4.0%	6.8%	3.7%
HTML 4.01 Transitional	22.2%	8.3%	13.8%	17.2%	19.9%	24.9%	19.1%	10.6%
XHTML 1.0 Strict	0.0%	0.3%	0.6%	1.5%	4.6%	1.4%	1.8%	0.4%
XHTML 1.0 Transitional	61.1%	48.4%	54.5%	51.8%	49.3%	46.6%	53.6%	34.0%
Other	5.6%	0.6%	1.8%	2.8%	3.0%	2.4%	2.2%	0.8%
No Document Type	5.6%	38.4%	22.3%	20.3%	13.8%	20.7%	16.5%	50.4%

Figure 25 shows the number of websites per 1000 sites that had valid document type declarations as a function of the ranking of the websites. There is a slight downward trend, which means that less popular websites are less likely to have valid document type declarations. The opposite trend can be seen in Figure 26 where the number of websites without a valid document type declaration per 1000 sites is shown as a function of ranking. A Spearman's correlation showed that these trends were negligible.

Figure 25: Valid Document Types versus Ranking

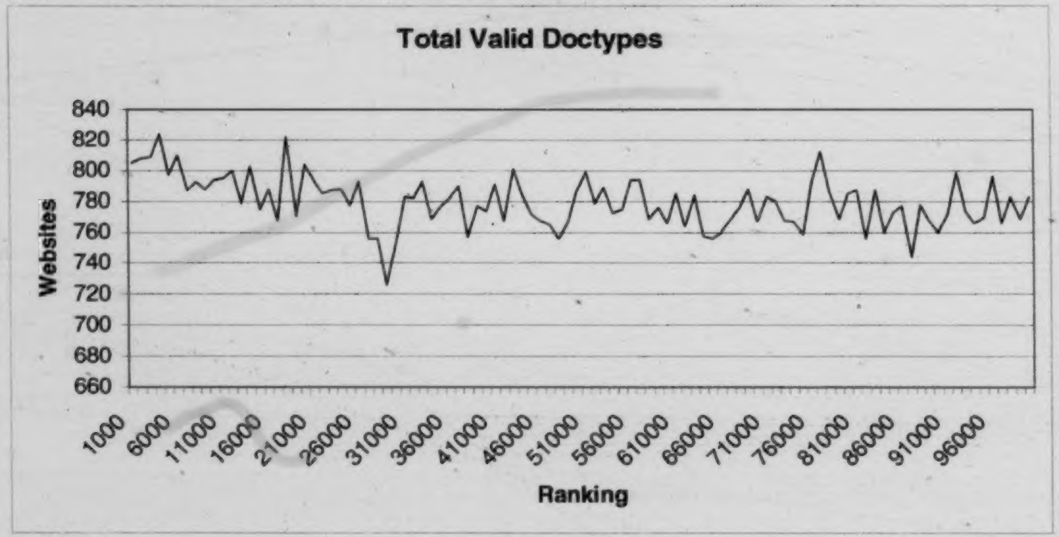

Figure 26: No Document Type versus Ranking

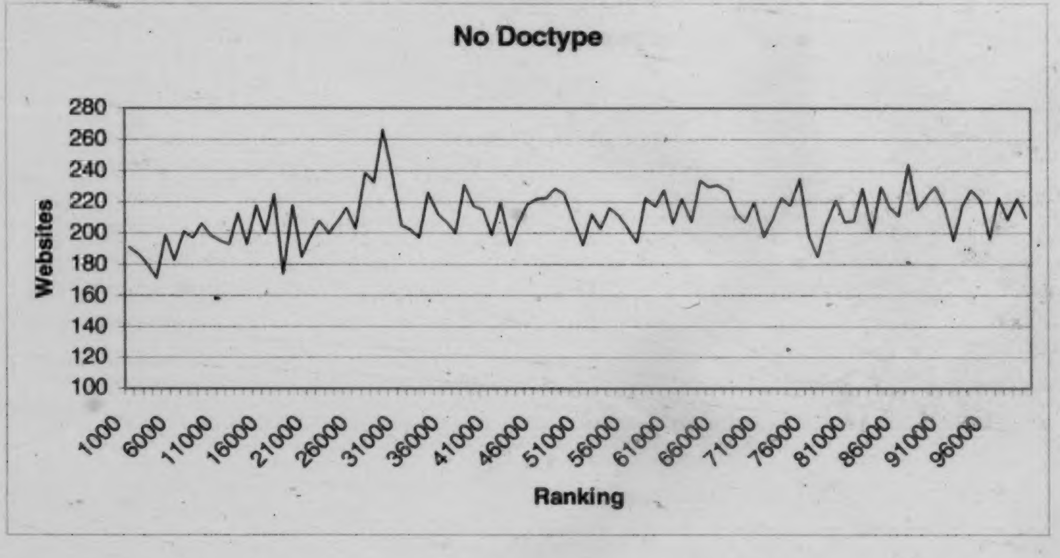

Table 48 shows the results of Spearman's correlation between website ranking and whether or not a website had a valid document type. Although the relationship is statistically significant (p<0.001) the R value is so low that the results are negligible.

Table 48: Spearman's Rho, R, and R^2 for Valid Doctypes and Website Ranking

Rho	-0.015	R	-0.016
p	0.000	Upper	0.000
Upper	0.005	Lower	-0.031
p	1.000	R^2	0.000
Lower	-0.035	Upper	0.000
p	0.000	Lower	0.001

A total of 31 valid character sets were found during this survey. Table 49 shows the number of websites with each type of character set. The character sets utf-8, iso-8859-1 and gb2312 account for 75.5% of all websites. utf-8 is an 8-bit encoding of Unicode characters, iso-859-1 is an encoding of Latin characters and symbols, and gb2312 is an encoding of simplified Chinese. shift_jis (Japanese encoding) and big5 (Chinese encoding) are used on 4.6% and 2.0% respectively of all websites. The Microsoft Windows encoding of the Latin alphabet, windows-1252, accounts for 3.3% of websites and the Microsoft Windows encoding of Arabic script, windows-1256 is used on 1.6% of websites. Another 6.7% of websites had an invalid character set or did not specify a character set. All other character sets that were found represented less than 1.0% (less than 1000 websites) of all websites surveyed.

Table 49: Character Sets Found

Character Set	Websites	Percentage
utf-8	34409	34.4%
iso-8859-1	28273	28.3%
gb2312	12791	12.8%

No Charset	4913	4.9%
shift_jis	4595	4.6%
windows-1252	3339	3.3%
big5	2038	2.0%
Invalid	1824	1.8%
windows-1256	1563	1.6%
euc-kr	995	1.0%
windows-1251	991	1.0%
euc-jp	888	0.9%
iso-8859-9	622	0.6%
iso-8859-2	519	0.5%
windows-1254	415	0.4%
windows-1255	392	0.4%
windows-1250	311	0.3%
iso-8859-7	234	0.2%
us-ascii	192	0.2%
iso-8859-15	186	0.2%
windows-1253	155	0.2%
koi8-r	101	0.1%
tis-620	94	0.1%
windows-1257	45	0.0%
iso-2022-jp	34	0.0%
iso-8859-8	22	0.0%
utf-16	21	0.0%
iso-8859-8-I	12	0.0%
iso-8859-5	9	0.0%
gb18030	7	0.0%
Macintosh	4	0.0%
koi8-u	3	0.0%
iso-8859-10	2	0.0%

Table 50 shows the percentage of websites in each continent that uses each type of character set. Only character sets that are used in over 1.0% of websites are examined individually. Less used character sets are combined into the Other category. Because the character set used is dependent to some extent on the language that a website is written in, it is expected that there are large differences between continents for the character sets. The Asian language character sets gb2312, shift_jis, and big5 are used predominately in Asia while windows-1256 (Arabic) is used predominately in Africa. Although all continents have a large percentage of websites that use utf-8, iso-8859-1, and windows-1252, Asia has far fewer sites using these character sets. Asia also has a much larger number of invalid character sets while Asia and Africa have larger numbers of websites that do not specify a character set.

Table 50: Percentage of Character Sets in Each Continent

	Africa	Asia	Europe	North America	Oceania	South America	Unknown
utf-8	44.1%	18.7%	33.5%	45.6%	46.4%	31.2%	8.5%
iso-8859-1	21.1%	2.7%	47.8%	38.4%	39.9%	59.0%	4.0%
Gb2312	0.0%	38.9%	0.2%	0.5%	0.9%	0.0%	8.6%
No Charset	6.2%	7.1%	2.1%	2.8%	2.3%	3.8%	69.4%
shift_jis	0.0%	13.2%	0.0%	0.6%	1.2%	0.0%	4.7%
Invalid	0.4%	9.9%	0.9%	1.1%	2.1%	0.9%	1.9%
windows-1252	7.5%	0.3%	3.3%	5.3%	4.6%	4.7%	0.4%
big5	0.0%	5.0%	0.1%	0.8%	0.6%	0.2%	1.5%
windows-1256	20.3%	0.6%	0.8%	2.5%	0.8%	0.0%	0.2%
Other	0.4%	3.6%	11.2%	2.4%	1.2%	0.1%	0.7%

Table 51 shows the results of Fisher's Exact Test (2-tail) comparing Asia against all other continents for utf-8, iso-8859-1, windows-1252. The differences between Asia and all other continents are statistically significant ($p<0.05$) except for the Unknown category for windows-1252 ($p<0.601$). These differences are likely due to the need to use character sets that support Asian characters on websites in Asian countries.

Table 51: Fisher's Exact Test (2-tail) for Asia against all other Continents

	Africa	Europe	North America	Oceania	South America	Unknown
utf-8	0.000	0.000	0.000	0.000	0.000	0.000
iso-8859-1	0.000	0.000	0.000	0.000	0.000	0.006
windows-1252	0.000	0.000	0.000	0.000	0.000	0.601

The percentage of websites using each character set in each GDP PPP per capita category are shown in Table 52. There is no clear relationships between GDP PPP per capita and the use of any specific character set as the data here closely represents what was seen in the by continent analysis in Table 50. China is in the less than $10000 USD category and has the largest number of websites using gb2312, Japan is in the greater than $30000 USD category and has the largest number of websites using shift_jis, and Taiwan is in the greater than $20000 USD category and has the largest number of websites using big5. The large number of invalid websites seen in the greater than $20000 USD category are due largely to Korea. Of the 1755 Korean websites surveyed, 60.0% had specified an invalid character set.

Table 52: Percentage of Character Sets in Each GDP PPP per capita (USD) Category

	<10000	>10000	>20000	>30000	>40000	Unknown
utf-8	18.3%	26.0%	29.4%	30.5%	45.5%	12.3%
iso-8859-1	4.5%	23.0%	17.8%	34.1%	38.3%	8.2%
Gb2312	60.0%	0.3%	0.4%	0.4%	0.5%	8.0%
No Charset	8.4%	3.4%	4.2%	3.0%	2.8%	62.4%
shift_jis	0.1%	0.0%	0.5%	17.8%	0.6%	4.2%
Invalid	3.6%	1.9%	17.7%	6.2%	1.1%	1.7%
windows-1252	0.5%	2.3%	1.6%	2.6%	5.4%	0.7%
big5	0.1%	0.3%	14.0%	3.1%	0.8%	1.7%
windows-1256	0.4%	3.8%	0.9%	0.7%	2.6%	0.2%
Other	4.1%	39.2%	13.5%	1.6%	2.5%	0.8%

The percentage of each Character Set found in each e-Readiness category is shown in Table 53. Again, there is no clear trend in the data. As with the Document Type data, similar values are seen in the less than $10000 USD GDP PPP category and 3.xx e-Readiness category as well as in the greater than $40000 USD GDP PPP category and the 8.xx e-Readiness category.

Table 53: Percentage of Character Sets in Each e-Readiness Category

	2.xx	3.xx	4.xx	5.xx	6.xx	7.xx	8.xx	Unknown
utf-8	44.4%	16.8%	23.7%	34.9%	30.8%	21.2%	44.0%	20.9%
iso-8859-1	5.6%	2.0%	16.2%	40.6%	30.0%	17.1%	39.7%	15.2%
gb2312	0.0%	65.0%	0.1%	0.4%	0.1%	0.3%	0.5%	5.5%
No Charset	5.6%	8.8%	4.3%	3.3%	1.9%	3.9%	2.8%	43.1%
shift_jis	11.1%	0.1%	0.1%	0.0%	0.0%	29.5%	0.6%	2.8%
Invalid	5.6%	3.2%	8.2%	0.5%	1.3%	17.0%	0.8%	1.4%
windows-1252	11.1%	0.2%	1.7%	3.8%	3.8%	1.0%	5.0%	2.1%
big5	5.6%	0.1%	0.2%	0.4%	0.0%	6.1%	1.9%	1.1%
windows-1256	0.0%	0.3%	4.3%	0.2%	0.1%	0.2%	2.2%	3.6%
Other	11.1%	3.5%	41.3%	15.8%	32.1%	3.7%	2.7%	4.3%

Figure 27 shows the number of websites with valid character sets as a function of website ranking while Figure 28 shows the number of websites with an invalid or missing character set as a function of website ranking. These graphs show a very small decrease in valid character sets as website ranking decreases.

Figure 27: Valid Character Sets versus Ranking

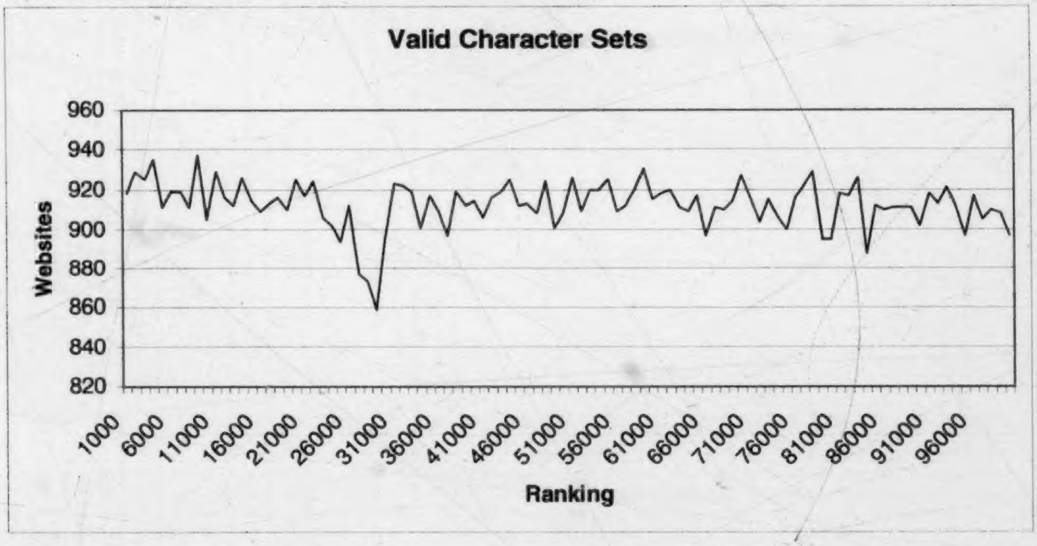

Figure 28: Invalid or Missing Character Sets versus Ranking

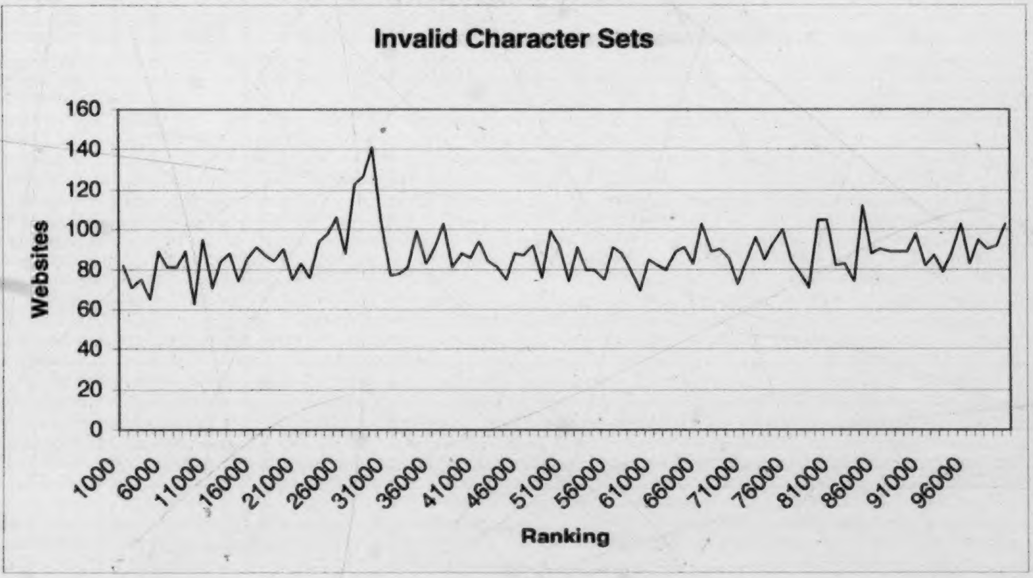

Table 54 shows the results of Spearman's correlation between valid character sets and website ranking. The relationship is statistically significant ($p<0.001$) however the R value is so low that the results are negligible.

Table 54: Spearman's Rho, R, and R^2 for Valid Charsets and Website Ranking

Rho	-0.012	R	-0.016
p	0.000	Upper	0.016
Upper	0.008	Lower	-0.031
p	0.000	R^2	0.000
Lower	-0.032	Upper	0.000
p	0.000	Lower	0.001

Table 55 shows the number of websites that had each type of warning. Note that not all warnings given in Table 30 were found in this survey. Of the warnings that were found, W04 and W09 were found on a large number of sites. These warning correspond to a missing character set and missing document type respectively where the W3C validator used default character sets and document types to validate the page. It is possible that this is due to web developers relying on browsers to assume a default character set and document type instead of specifying one. If a character set or document type was not found by the W3C validator a fallback option was tried in order to tentatively validate the website. The only other warning that affects more than 1% of the websites is W19, which refers to a conflict character set declarations in the http header and <meta> element. Missing or invalid character sets and document types have repeatedly appeared as common problems in the websites in this study.

Table 55: Number of Websites with each Warning

Warning	Websites
W04	12703

W06	809
W07	44
W09	42495
W11	858
W18	61
W19	4296
W20	14
W21	420

The percentage of websites with each warning is given by country in Table 56. Only countries with more than 1% of the total websites are shown, the rest are included under the Other category. Large variations are seen in the percentage of websites with each warning in the different countries. These differences will be examined in more detail in a by continent analysis. Note that these columns will not add up to 100%. Each cell in the table represents the percent of websites in that country that had the specific warning. A website may have more than one warning and a single warning will appear on many websites.

Table 56: Percentage of Websites with Warnings in each Country

Country	W04	W06	W07	W09	W11	W18	W19	W20	W21
United States	17.4%	1.0%	0.0%	44.6%	0.9%	0.1%	6.0%	0.0%	0.3%
China	6.9%	0.2%	0.1%	43.8%	0.9%	0.0%	1.8%	0.0%	0.5%
Japan	4.7%	0.5%	0.0%	28.0%	0.6%	0.0%	1.1%	0.0%	0.4%
United Kingdom	11.5%	1.3%	0.0%	30.2%	0.8%	0.3%	6.3%	0.1%	0.3%
Canada	15.8%	0.9%	0.0%	43.6%	1.4%	0.1%	5.2%	0.0%	0.3%
Germany	9.2%	1.9%	0.0%	31.8%	1.1%	0.1%	3.6%	0.0%	0.6%
France	6.4%	1.5%	0.1%	38.9%	1.0%	0.2%	2.5%	0.1%	0.9%
Republic Of Korea	15.5%	0.5%	0.0%	60.2%	0.2%	0.0%	1.0%	0.0%	0.1%
Netherlands	15.1%	0.6%	0.0%	43.9%	0.4%	0.1%	4.4%	0.0%	0.3%
Hong Kong	16.1%	0.2%	0.0%	56.8%	0.5%	0.0%	3.5%	0.0%	1.2%
Taiwan	9.1%	0.5%	0.2%	59.0%	1.1%	0.0%	1.3%	0.0%	1.4%
Spain	8.2%	1.6%	0.2%	43.1%	1.1%	0.1%	2.7%	0.0%	0.1%
Other	9.2%	0.9%	0.1%	40.7%	0.9%	0.1%	4.3%	0.0%	0.5%

The percentage of websites from each continent with each type of warning is shown in Table 57. Overall, Asia and Europe had fewer warnings while Africa and North America had more. Websites with an unknown continent had the least number of warnings however this may be due to many of these websites being unreachable at the time of the survey.

Table 57: Percentage of Websites with Warnings in each Continent

	Africa	Asia	Europe	North America	Oceania	South America	Unknown
W04	11.9%	7.6%	9.4%	17.4%	16.4%	12.1%	2.8%
W06	0.9%	0.3%	1.3%	1.0%	1.1%	0.6%	0.1%
W07	0.0%	0.1%	0.0%	0.0%	0.1%	0.1%	0.0%
W09	50.7%	43.3%	36.7%	44.6%	38.1%	49.9%	14.4%
W11	2.2%	0.8%	0.9%	0.9%	0.8%	1.4%	0.0%
W18	0.0%	0.0%	0.2%	0.1%	0.2%	0.1%	0.0%
W19	4.8%	2.0%	4.2%	5.9%	6.8%	2.4%	2.1%
W20	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%
W21	0.9%	0.5%	0.5%	0.3%	0.2%	0.3%	0.0%
Total	71.4%	54.6%	53.2%	70.2%	63.9%	66.8%	19.4%

Table 58 shows an analysis of the percentage of website with each warning with W04 and W09 removed. In this table Africa, Europe, North America, and Oceania have a far higher percentage of websites with warnings than do Asia and South America. The Unknown category has the lowest percentage of websites with warning, which is likely due to the high number of websites in this category that were unreachable, as stated before.

Table 58: Percentage of Websites with Warnings in each Continent with W04 and W09 Withdrawn

	Africa	Asia	Europe	North America	Oceania	South America	Unknown
W06	0.9%	0.3%	1.3%	1.0%	1.1%	0.6%	0.1%
W07	0.0%	0.1%	0.0%	0.0%	0.1%	0.1%	0.0%
W11	2.2%	0.8%	0.9%	0.9%	0.8%	1.4%	0.0%
W18	0.0%	0.0%	0.2%	0.1%	0.2%	0.1%	0.0%
W19	4.8%	2.0%	4.2%	5.9%	6.8%	2.4%	2.1%
W20	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%
W21	0.9%	0.5%	0.5%	0.3%	0.2%	0.3%	0.0%
Total	8.8%	3.7%	7.1%	8.2%	9.3%	4.9%	2.2%

Table 59 shows the results of Fisher's Exact Test (2-tail) for W04, which occurs when no character set is found and the default of utf-8 is used instead. This analysis found that no significant difference exists between websites with W04 warnings in Africa websites with this warning found in Europe, Oceania, and South America ($p > 0.05$). Also, the differences in the number of websites found in North America and Oceania that had the W04 warning were not found to be statistically significant ($p > 0.05$). The differences in all other relationships between continents were found to be statistically significant ($p < 0.05$).

Table 59: Fisher's Exact Test (2-tail) for W04 by Continent

	Africa	Asia	Europe	North America	Oceania	South America	Unknown
Africa	1.000	0.023	0.206	0.028	0.101	1.000	0.000
Asia		1.000	0.000	0.000	0.000	0.000	0.000
Europe			1.000	0.000	0.000	0.010	0.000
North America				1.000	0.478	0.000	0.000
Oceania					1.000	0.008	0.000
South America						1.000	0.000
Unknown							1.000

Table 60 shows the results of Fisher's Exact Test (2-tail) for W06, which occurs when no file mode is found and SGML is used by default. Most of the results between continents are related (p > 0.05) with a few exceptions. The results for Asia have no relation to Europe, North America, and Oceania. Europe and North America are not related. As well the differences between the Unknown category and Europe, North America, or Oceania were found to be statistically significant.

Table 60: Fisher's Exact Test (2-tail) for W06 by Continent

	Africa	Asia	Europe	North America	Oceania	South America	Unknown
Africa	1.000	0.180	1.000	1.000	1.000	0.636	0.065
Asia		1.000	0.000	0.000	0.001	0.233	0.194
Europe			1.000	0.001	0.761	0.061	0.000
North America				1.000	0.608	0.295	0.000
Oceania					1.000	0.300	0.001
South America						1.000	0.088
Unknown							1.000

Table 61 shows the results of Fisher's Exact Test (2-tail) for W07, which occurs when the content type is not supported. The only differences found that were statistically significant were between Europe and North America (p<0.05).

Table 61: Fisher's Exact Test (2-tail) for W07 by Continent

	Africa	Asia	Europe	North America	Oceania	South America	Unknown
Africa	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Asia		1.000	0.559	0.013	0.458	0.453	1.000
Europe			1.000	0.211	0.378	0.374	1.000
North America				1.000	0.228	0.225	1.000
Oceania					1.000	1.000	1.000
South America						1.000	0.418
Unknown							1.000

Table 62 shows the results of Fisher's Exact Test (2-tail) for W09, which occurs when the fallback FPI (formal public identifier) is used because no document type was found. The only differences that were not statistically significant were between three sets of continent categories; Africa and North America (p<0.071), Europe and Oceania (p<0.414), and Africa and South America (p<0.882).

Table 62: Fisher's Exact Test (2-tail) for W09 by Continent

	Africa	Asia	Europe	North America	Oceania	South America	Unknown
Africa	1.000	0.027	0.000	0.071	0.001	0.882	0.000
Asia		1.000	0.000	0.000	0.002	0.000	0.000
Europe			1.000	0.000	0.414	0.000	0.000
North America				1.000	0.000	0.002	0.000
Oceania					1.000	0.000	0.000
South America						1.000	0.000
Unknown							1.000

Table 63 shows the results of Fisher's Exact Test (2-tail) for W11, which occurs when a namespace declaration is found but the document type is not XML. The percentage of websites found in Africa and Asia with this warning were found to be unrelated (p<0.05) as were the percentage of websites in the Unknown category with this warning and any other continent category (p<0.05). The results for all other categories were not statistically significant.

Table 63: Fisher's Exact Test (2-tail) for W11 by Continent

	Africa	Asia	Europe	North America	Oceania	South America	Unknown
Africa	1.000	0.034	0.056	0.058	0.073	0.363	0.000
Asia		1.000	0.202	0.050	1.000	0.079	0.000
Europe			1.000	0.000	0.086	0.886	0.000
North America				1.000	0.859	0.155	0.000

Oceania					1.000	0.257	0.002
South America						1.000	0.000
Unknown							1.000

Table 64 shows the results of Fisher's Exact Test (2-tail) for W18, which occurs when there is a character set conflict in the HTTP header and the XML. Most of the differences in the results from the different continent categories and not statistically significant (p > 0.05) with the exception of Asia and Europe (p<0.001), Asia and North America (p<0.001), Asia and Oceania (p<0.001), and Europe and North America (p<0.05).

Table 64: Fisher's Exact Test (2-tail) for W18 by Continent

	Africa	Asia	Europe	North America	Oceania	South America	Unknown
Africa	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Asia		1.000	0.000	0.000	0.007	0.104	1.000
Europe			1.000	0.002	0.648	1.000	0.414
North America				1.000	0.116	0.431	1.000
Oceania					1.000	1.000	0.178
South America						1.000	0.418
Unknown							1.000

Table 65 shows the results of Fisher's Exact Test (2-tail) for W19, which occurs when there is a character set conflict between the HTTP header and the <meta> element. The differences in the results from Africa and Europe (p<0.616), North America (p<0.670), and Oceania (p<0.071) were all found to not be statistically significant. The differences in the results from Asia and South America (p<0.393) and the Unknown category (p<0.755) were also not statistically significant. The differences in the results from North America and Oceania (p<0.254) as well as from South America and the Unknown category (p<0.765) were not statistically significant.

Table 65: Fisher's Exact Test (2-tail) for W19 by Continent

	Africa	Asia	Europe	North America	Oceania	South America	Unknown
Africa	1.000	0.006	0.616	0.670	0.362	0.071	0.034
Asia		1.000	0.000	0.000	0.000	0.393	0.755
Europe			1.000	0.000	0.001	0.005	0.000
North America				1.000	0.254	0.000	0.000
Oceania					1.000	0.000	0.000
South America						1.000	0.765
Unknown							1.000

Table 66 shows the results of Fisher's Exact Test (2-tail) for W20, which occurs when there is a character set conflict between the <meta> element and the XML. None of the differences between these results were statistically significant.

Table 66: Fisher's Exact Test (2-tail) for W20 by Continent

	Africa	Asia	Europe	North America	Oceania	South America	Unknown
Africa	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Asia		1.000	0.051	0.490	0.080	1.000	1.000
Europe			1.000	0.163	0.271	1.000	1.000
North America				1.000	0.121	1.000	1.000
Oceania					1.000	1.000	0.422
South America						1.000	1.000
Unknown							1.000

Table 67 shows the results of Fisher's Exact Test (2-tail) for W21, which occurs when the character set is utf-8 and the document contains a byte order mark (BOM). Most of the differences between these results not statistically significant ($p > 0.05$). The exceptions are Asia and North America ($p<0.001$), Europe and North America ($p<0.05$), the Unknown category and Asia ($p<0.05$), and the Unknown category and Europe ($p<0.05$).

Table 67: Fisher's Exact Test (2-tail) for W21 by Continent

	Africa	Asia	Europe	North America	Oceania	South America	Unknown
Africa	1.000	0.356	0.298	0.174	0.183	0.271	0.024
Asia		1.000	0.320	0.000	0.248	0.638	0.002
Europe			1.000	0.009	0.444	0.800	0.006
North America				1.000	1.000	0.769	0.037
Oceania					1.000	0.685	0.178
South America						1.000	0.073
Unknown							1.000

Table 68 shows the percentage of websites with warnings in each GDP PPP per capita category. There is no clear trend in total warnings versus GDP. The differences seen are in part due to the differences seen in the by continent analysis. The United States dominates both the North American continent websites and the GDP PPP per capita greater than $40000 USD category while China dominates the Asian continent and the GDP PPP per capita less than $10000 USD.

Table 68: Percentage of Warnings in Each GDP PPP per capita (USD) Category

	<10000	>10000	>20000	>30000	>40000	Unknown
W04	7.3%	8.9%	11.0%	9.7%	17.4%	5.0%
W06	0.3%	0.9%	0.9%	0.9%	1.0%	0.1%
W07	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%
W09	44.7%	49.3%	52.3%	35.0%	44.4%	18.9%
W11	0.9%	0.9%	0.9%	0.8%	0.9%	0.0%
W18	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%
W19	2.4%	2.8%	2.2%	3.6%	5.9%	2.0%
W20	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
W21	0.5%	0.5%	0.5%	0.5%	0.3%	0.1%

The percentage of websites that had each warning as well as the total percentage of websites with warnings for each e-Readiness category are shown in Table 69. The results for e-Readiness are similar to the GDP PPP results. No clear trend is seen in the data with respect to e-Readiness.

Table 69: Percentage of Warnings in Each e-Readiness Category

	2.xx	3.xx	4.xx	5.xx	6.xx	7.xx	8.xx	Unknown
W04	16.7%	6.9%	9.1%	11.5%	9.0%	7.3%	16.2%	7.5%
W06	0.0%	0.2%	0.9%	0.4%	1.1%	0.8%	1.0%	0.4%
W07	0.0%	0.1%	0.2%	0.1%	0.2%	0.0%	0.0%	0.0%
W09	44.4%	44.7%	48.9%	44.6%	37.9%	39.4%	42.9%	29.1%
W11	0.0%	0.9%	1.1%	0.6%	0.9%	0.7%	0.9%	0.3%
W18	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.1%	0.0%
W19	5.6%	1.9%	7.6%	2.6%	4.5%	1.7%	5.7%	2.8%
W20	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
W21	5.6%	0.5%	0.2%	0.3%	0.4%	0.6%	0.4%	0.6%

The total number of warnings found as a function of website ranking is shown in Figure 29. No clear trend is seen here.

Figure 29: Total Number of Warnings versus Website Ranking

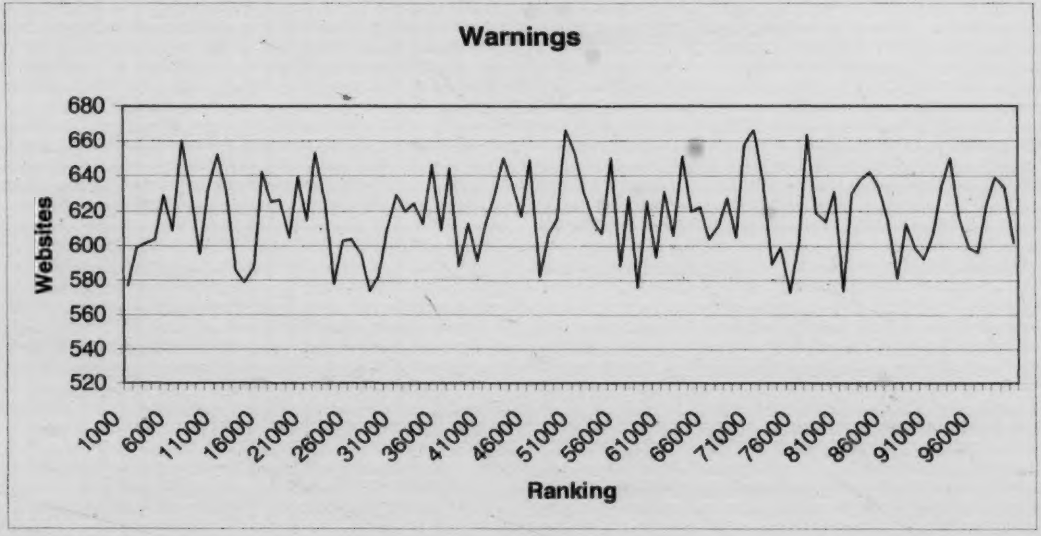

Table 70 shows the results of Spearman's correlation between website ranking and each of the nine warnings that were found. The only warning that had a statistically significant relationship with website ranking was W18 (p<0.05). This relationship had an R value of 0.016 which means that the results are negligible.

Table 70: Spearman's Rho, R, and R^2 for Warnings and Website Ranking

W04	Rho	-0.002	R	0.000
	p	0.465	Upper	0.016
	Upper	0.018	Lower	-0.016
	p	0.000	R^2	0.000
	Lower	-0.022	Upper	0.000
	p	0.000	Lower	0.000
W06	Rho	0.007	R	0.000
	p	0.031	Upper	0.031
	Upper	0.027	Lower	-0.016
	p	0.000	R^2	0.000
	Lower	-0.013	Upper	0.001
	p	0.000	Lower	0.000

W07	Rho	-0.003	R	0.000
	p	0.342	Upper	0.016
	Upper	0.017	Lower	-0.031
	p	0.000	R^2	0.000
	Lower	-0.023	Upper	0.000
	p	0.000	Lower	0.001
W09	Rho	0.000	R	0.000
	p	0.882	Upper	0.016
	Upper	0.020	Lower	-0.016
	p	0.000	R^2	0.000
	Lower	-0.019	Upper	0.000
	p	0.000	Lower	0.000
W11	Rho	0.004	R	0.000
	p	0.188	Upper	0.031
	Upper	0.024	Lower	-0.016
	p	0.000	R^2	0.000
	Lower	-0.015	Upper	0.001
	p	0.000	Lower	0.000
W18	Rho	0.008	R	0.016
	p	0.011	Upper	0.031
	Upper	0.028	Lower	-0.016
	p	0.000	R^2	0.000
	Lower	-0.012	Upper	0.001
	p	0.000	Lower	0.000
W19	Rho	0.005	R	0.000
	p	0.090	Upper	0.031
	Upper	0.025	Lower	-0.016
	p	0.000	R^2	0.000
	Lower	-0.014	Upper	0.001
	p	0.000	Lower	0.000
W20	Rho	0.000	R	0.000
	p	0.965	Upper	0.016
	Upper	0.019	Lower	-0.016
	p	0.000	R^2	0.000
	Lower	-0.020	Upper	0.000
	p	0.000	Lower	0.000
W21	Rho	-0.003	R	0.000
	p	0.300	Upper	0.016
	Upper	0.016	Lower	-0.031
	p	0.000	R^2	0.000
	Lower	-0.023	Upper	0.000
	p	0.000	Lower	0.001

A surprisingly large number of websites (19.1%) produced a fatal error while being validated. Table 71 shows the fatal errors that were encountered and the number of websites that had each error. The fatal errors were dominated by problems with the character set (FE2) and problems with transcoding the document (FE3) as well as many unreachable sites (FE0). The error FE3 occurs when the web page has characters in it that are not in the character set the site specifies and so the page can not be transcoded. This trend is repeated here with both FE2 and FE3 being related to the use of character sets. The fatal error FE4 refers to problems with the document type on the website.

Table 71: Number of Websites with Each Fatal Error

Fatal Error Type	Number of Websites
FE0	4790
FE2	1824
FE3	12439
FE4	55

The percentage of websites with each fatal error is given by country in Table 72. Only countries with more than 1% of the total websites are shown, the rest are included under the Other category. While there is wide variation among the values of each error in the different countries, a few trends stand out. The fatal error associated with character set problems (FE2) is most prominent in Japan and Korea while the fatal error associated with transcoding problems (FE3) is most prominent in China. These trends will be examined further in a by continent analysis.

Table 72: Percentage of Fatal Errors in Each Country

Country	FE0	FE2	FE3	FE4

United States	2.7%	0.6%	10.0%	0.1%
China	8.9%	3.2%	26.0%	0.0%
Japan	4.0%	7.4%	8.4%	0.0%
United Kingdom	2.0%	0.5%	7.8%	0.1%
Canada	3.3%	0.7%	10.4%	0.2%
Germany	2.2%	0.5%	8.7%	0.1%
France	1.0%	0.3%	10.5%	0.0%
Republic Of Korea	4.8%	8.1%	13.7%	0.0%
Netherlands	2.4%	0.8%	9.0%	0.1%
Hong Kong	6.1%	1.2%	10.6%	0.1%
Taiwan	6.6%	1.0%	8.8%	0.0%
Spain	2.0%	0.6%	12.8%	0.1%
Other	9.3%	2.0%	7.6%	0.0%

Table 73 shows the percentage of websites in each continent with each fatal error. Asia has a much larger number of fatal errors than any other continent. These errors are mostly due to character set problems and errors in transcoding however Asia also has more unreachable sites than any other continent.

Table 73: Percentage of Fatal Errors in Each Continent

	Africa	Asia	Europe	North America	Oceania	South America	Unknown
FE0	6.2%	7.0%	2.0%	2.7%	2.2%	3.6%	69.2%
FE2	0.0%	4.4%	0.8%	0.6%	0.6%	0.9%	0.9%
FE3	11.0%	18.5%	8.7%	10.0%	6.8%	14.0%	3.6%
FE4	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%
Total	17.2%	29.8%	11.5%	13.4%	9.6%	18.5%	73.8%

Table 74 shows the percentage of websites with each fatal error in each continent with FE0 removed. Because most of the fatal errors in the Unknown category were due to unreachable websites (FE0), this category now has a much lower percentage of websites with fatal errors. Asia still has far more fatal errors than any other continent due to the large number of websites with transcoding errors (FE3).

Table 74: Percentage of Fatal Errors in Each Continent without FE0

	Africa	Asia	Europe	North America	Oceania	South America	Unknown
FE2	0.0%	4.4%	0.8%	0.6%	0.6%	0.9%	0.9%
FE3	11.0%	18.5%	8.7%	10.0%	6.8%	14.0%	3.6%
FE4	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%
Total	11.0%	22.9%	9.5%	10.7%	7.3%	14.9%	4.5%

Table 75 shows the results of Fisher's Exact Test (2-tailed) for FE0. The differences between most results were found to be statistically significant ($p<0.05$) however there are a few exceptions. The difference found between the results from South America and Africa ($p<0.093$), North America ($p<0.119$), and Oceania ($p<0.091$) were not statistically significant. The differences between Oceania and Europe ($p<0.623$), Oceania and North America ($p<0.408$), and Asia and Africa ($p<0.793$) were also found to be not statistically significant.

Table 75: Fisher's Exact Test (2-tail) for FE0 by Continent

	Africa	Asia	Europe	North America	Oceania	South America	Unknown
Africa	1.000	0.793	0.000	0.006	0.004	0.093	0.000
Asia		1.000	0.000	0.000	0.000	0.000	0.000
Europe			1.000	0.000	0.623	0.002	0.000
North America				1.000	0.408	0.119	0.000
Oceania					1.000	0.091	0.000
South America						1.000	0.000
Unknown							1.000

Table 76 shows the results of Fisher's Exact Test (2-tailed) for FE2. There are few statistically significant differences in the results for FE2 with only two exceptions. The first one is between North America and Europe ($p<0.05$) and the second is between Asia and every other continent category (p<0.001). FE2 relates to an error with the character set in the document and Asia had far more websites that this occurred on than any other continent.

Table 76: Fisher's Exact Test (2-tail) for FE2 by Continent

	Africa	Asia	Europe	North America	Oceania	South America	Unknown
Africa	1.000	0.000	0.420	0.643	0.590	0.371	0.232
Asia		1.000	0.000	0.000	0.000	0.000	0.000
Europe			1.000	0.011	0.689	0.551	0.608
North America				1.000	1.000	0.176	0.176
Oceania					1.000	0.419	0.453
South America						1.000	1.000
Unknown							1.000

Table 77 shows the results of Fisher's Exact Test (2-tailed) for FE3. The differences in most of these results are statistically significant (p<0.05). Exceptions are Africa and Europe (p<0.235), North America (p<0.581), and South America (p<0.275).

Table 77: Fisher's Exact Test (2-tail) for FE3 by Continent

	Africa	Asia	Europe	North America	Oceania	South America	Unknown
Africa	1.000	0.003	0.235	0.581	0.036	0.275	0.000
Asia		1.000	0.000	0.000	0.000	0.001	0.000
Europe			1.000	0.000	0.044	0.000	0.000
North America				1.000	0.001	0.000	0.000
Oceania					1.000	0.000	0.001
South America						1.000	0.000
Unknown							1.000

Table 78 shows the results of Fisher's Exact Test (2-tailed) for FE4. The only difference for this fatal error that is statistically significant is between Europe and Asia (p<0.05).

Table 78: Fisher's Exact Test (2-tail) for FE4 by Continent

	Africa	Asia	Europe	North America	Oceania	South America	Unknown
Africa	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Asia		1.000	0.038	0.000	1.000	1.000	1.000
Europe			1.000	0.055	1.000	1.000	1.000
North America				1.000	1.000	1.000	0.631
Oceania					1.000	1.000	1.000
South America						1.000	1.000
Unknown							1.000

Table 79 gives the number of websites with each fatal error for each GDP PPP per capita category. No clear trend is seen in this data however the category of GDP PPP per capita of less than $10000 USD has a much higher number of fatal errors than any other category. This category is dominated largely by Asian nations, specifically China.

Table 79: Percentage of Fatal Errors in Each GDP PPP per capita (USD) Category

	<10000	>10000	>20000	>30000	>40000	Unknown
FE0	8.3%	3.3%	4.0%	2.8%	2.7%	62.2%
FE2	3.5%	1.7%	3.0%	2.6%	0.6%	0.8%
FE3	23.7%	7.5%	10.0%	9.0%	10.0%	3.8%
FE4	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%
Total	35.4%	12.6%	17.0%	14.5%	13.4%	66.9%

The percentage of websites with each fatal error as well as the total percentage of websites with fatal errors is shown for each e-Readiness category in Table 80. The results of the e-Readiness analysis follow closely those of the GDP PPP analysis. The e-Readiness category of 3.xx, which is dominated by Chinese websites, has the largest percentage of websites with fatal errors. The 2.xx category is an anomaly in this data with only 5.6% of sites having a fatal error.

Table 80: Percentage of Fatal Errors in Each e-Readiness Category

	2.xx	3.xx	4.xx	5.xx	6.xx	7.xx	8.xx	Unknown
FE0	5.6%	8.6%	4.2%	3.1%	1.9%	3.7%	2.7%	43.0%
FE2	0.0%	3.2%	8.2%	0.5%	1.3%	4.8%	0.6%	0.8%
FE3	0.0%	24.5%	7.5%	14.6%	7.6%	9.6%	9.8%	4.8%
FE4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%
Total	5.6%	36.2%	19.9%	18.1%	10.7%	18.1%	13.2%	48.7%

Figure 30 shows a very slight increase in the number of fatal errors as the ranking of websites decreases. This increase coincides with the increase seen in Figure 28 of the number of invalid or missing character sets as a function of website ranking as most of the fatal errors are associated with character set problems.

Figure 30: Total Number of Websites with a Fatal Error versus Website Ranking

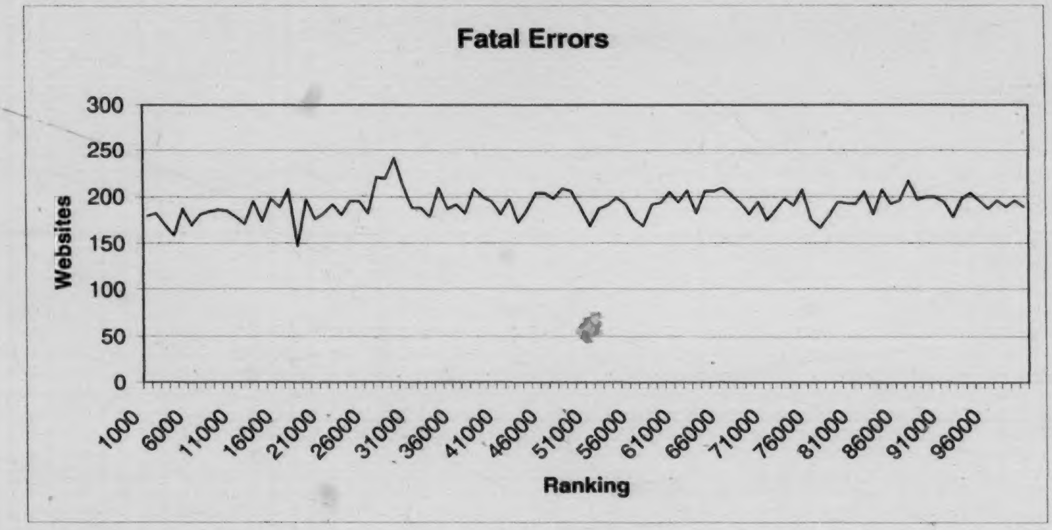

Table 81 shows the results of Spearman's correlation between website ranking and each fatal error that was found. A statistically significant relationship was found between website ranking and FE0 (p<0.001) and website ranking and FE2 (p<0.05) with all other relationships being not significant. The R values for the two significant relationships are 0.016 and 0.000 respectively which means that these results are negligible.

Table 81: Spearman's Rho, R, and R^2 for Fatal Errors and Website Ranking

FE0	Rho	0.017	R	0.016
	p	0.000	Upper	0.031
	Upper	0.037	Lower	0.000
	p	0.000	R^2	0.000
	Lower	-0.003	Upper	0.001
	p	1.000	Lower	0.000
FE2	Rho	-0.007	R	0.000
	p	0.020	Upper	0.016
	Upper	0.013	Lower	-0.031
	p	0.000	R^2	0.000

	Lower	-0.027	Upper	0.000
	p	0.000	Lower	0.001
FE3	Rho	0.002	R	0.000
	p	0.522	Upper	0.016
	Upper	0.022	Lower	-0.016
	p	0.000	R^2	0.000
	Lower	-0.018	Upper	0.000
	p	0.000	Lower	0.000
FE4	Rho	0.001	R	0.000
	p	0.660	Upper	0.016
	Upper	0.021	Lower	-0.016
	p	0.000	R^2	0.000
	Lower	-0.018	Upper	0.000
	p	0.000	Lower	0.000

Syntax errors were the errors given by the SGML parser used by W3C's HTML validator. Table 82 shows the syntax errors that were encountered during this survey. The full list of possible syntax errors is given in Section **7.1** in the Appendix. This table gives the number of websites that had each type of syntax error as well as the average number of errors that each one of those websites had and the maximum number of syntax errors on any website. The syntax errors that were encountered represent a wide range of possible problems with a HTML document. About 2% of the errors found were the result of problems with tags in the document. This included missing start and end tags, or extra tags that were not matched. Another 47% of the errors found had to do with the occurrence of invalid or unknown characters, entities, and attributes. This included references to entities that were undefined, invalid characters or characters that are not SGML characters, invalid function names, and undefined attributes and elements. The other 51% of the errors involved the invalid use of the HTML language. These errors involved problems with the document type declaration, missing required elements or having them in the incorrect location, invalid values for attributes, and invalid or repeated declarations for functions, entities, and attributes.

Table 82: Number of Websites with each Type of Syntax Error

Error Type	Number of Websites	Errors per Website	Max Errors	Error Type	Number of Websites	Errors per Website	Max Errors
E8	57	1	1	E117	3	2	2
E15	17	1	1	E121	1692	4	165
E16	6	1	2	E122	1844	8	943
E22	53	9	40	E123	1650	2	332
E25	39731	6	345	E125	2300	11	599
E28	195	2	4	E127	58148	36	5280
E31	155	5	110	E131	21922	11	1822
E32	8	1	1	E137	1551	7	400
E38	832	4	738	E139	5562	51	94562
E39	19	1	1	E141	10731	23	2642
E42	240	4	72	E143	24	1	1
E46	451	1	9	E154	110	1	1
E47	636	1	2	E161	20	1	1
E48	1	1	1	E162	19	1	1
E53	5887	10	704	E163	727	1	1
E55	1708	1	25	E164	10	1	1
E60	7	1	1	E183	644	3	114
E61	273	2	108	E185	598	1	8
E62	4282	3	123	E187	5199	1	2
E63	11475	6	1467	E188	2	1	1
E64	42777	8	2151	E189	9	1	1
E65	25500	10	8743	E243	1	1	1
E66	8030	3	1467	E246	193	3	89
E67	19	1	1	E248	77	2	9
E68	25557	17	2550	E249	43	1	2
E70	8097	71	2944	E250	1	2	2
E73	23108	2	1287	E253	68	9	216
E74	3188	3	160	E257	4218	39	2053
E76	26616	11	3401	E306	42	1	2
E77	1	46	46	E323	76	1	1
E78	6122	2	195	E325	39737	111	17068
E79	44580	14	5468	E337	10	1	1
E81	4018	5	368	E338	39731	6	345
E82	24404	33	7421	E344	36495	1	3
E83	3	1	1	E378	40	1	1
E100	204	1	1	E380	5	5	18

E102	21	1	1	E387	238	4	110
E105	5842	5	503	E388	326	30	930
E106	12029	7	1418	E394	5733	39	4036
E107	1458	4	333	E400	7	16	56
E108	58784	8	128	E401	3	1	2
E109	613	6	225	E403	5300	38	4034
E111	1914	2	150	E404	4315	10	1931
E112	5908	5	801	E407	1281	10	535
E115	32	1	4	E410	2566	14	1461

Table 83 shows the total number of syntax errors for each country as well as the average number of syntax errors per website for that country. Countries that represent less than 1% of all websites in the study are grouped into the Other category.

Table 83: Total Syntax Errors per Country

Country	Syntax Errors	Syntax Errors per Website
United States	6294712	139
China	2147001	121
Japan	448071	66
United Kingdom	389287	110
Canada	325208	126
Germany	299080	123
France	252767	136
Republic Of Korea	270430	154
Netherlands	233345	154
Hong Kong	103780	72
Taiwan	153937	115
Spain	252137	203
Other	1634714	131

Table 84 shows the total number of syntax errors for each continent as well as the average number of syntax errors per website for each continent. The high number of syntax errors per website for all continents is a disturbing indicator of the quality of these sites.

Table 84: Total Syntax Errors per Continent

Continent	Syntax Errors	Syntax Error per Website
Africa	31420	138
Asia	3575361	112
Europe	2281012	137
North America	6662830	138
Oceania	102510	114
South America	92083	104
Unknown	59253	48

The total number of syntax errors for each GDP PPP per capita category as well as the average number of syntax errors per website for each category is shown in Table 85. There is no clear trend between GDP category and the number of syntax errors. However, the data here mirrors the data in the continent analysis with over 100 syntax errors per website in every category except the Unknown category. This data suggests that there is a lot of room for improvement in websites in all categories.

Table 85: Total Syntax Errors per GDP PPP per Capita (USD) Category

GDP (PPP) per Capita (USD)	Syntax Errors	Syntax Errors per Website
>40000	6352339	139
>30000	2444515	103
>20000	979232	157
>10000	404845	159
<10000	2548898	124
Unknown	74640	54

Table 86 shows the total number of syntax errors per e-Readiness category as well as the average number of syntax errors per website for each category. This data closely mirrors the GDP PPP data especially in the categories containing the United States and China.

Table 86: Total Syntax Errors per e-Readiness Category

e-Readiness	Syntax Errors	Syntax Errors per Website
8.xx	8009743	134

7.xx	1566129	111
6.xx	237095	142
5.xx	190032	122
4.xx	263771	146
3.xx	2383995	126
2.xx	1682	93
Unknown	152022	75

Figure 31 shows the total number of syntax errors as a function of website ranking. There is a clear decrease in syntax errors as website ranking decreases. Figure 32 shows the average number of syntax errors per website as a function of website ranking. There is no clear decrease in the number of syntax errors per website as website ranking decreases. The number of websites that have syntax errors decreases as website ranking decreases.

Figure 31: Syntax Errors Found as a function of Website Ranking

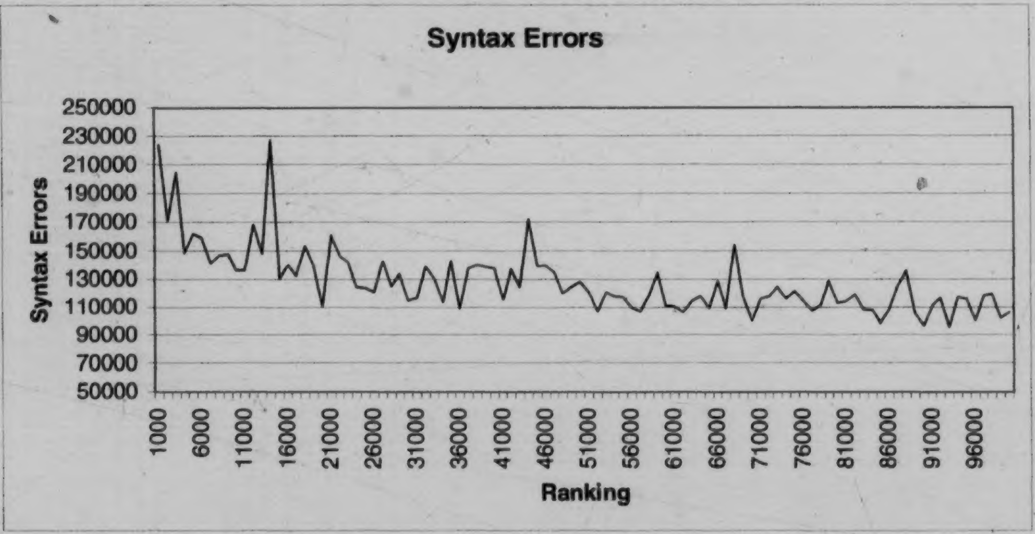

Figure 32: Syntax Errors Found per Website as a function of Website Ranking

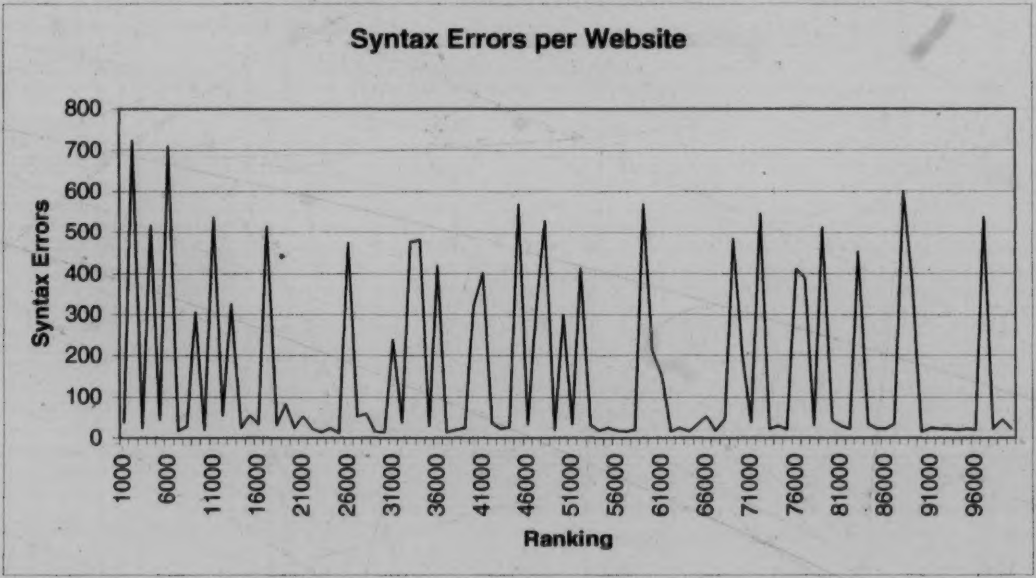

Table 87 shows the results of Spearman's correlation between website ranking and number of syntax errors. This relationship was found to be statistically significant ($p<0.001$). The value of R is negative (-0.031) which means that it is an inverse relationship, as ranking increases the number or syntax error decrease. However this relationship only accounts for 0.1% of the variance seen and is therefore negligible.

Table 87: Spearman's Rho, R, and R^2 for Syntax Errors and Website Ranking

Rho	-0.034	R	-0.031
p	0.000	Upper	-0.016
Upper	-0.014	Lower	-0.063
p	0.000	R^2	0.001
Lower	-0.054	Upper	0.000
p	0.000	Lower	0.004

4.5 CSS Survey

The W3C CSS Validator[16] was used to perform this survey. The validator was downloaded from the W3C site[17]. In order to automate the CSS validator, a wrapper was built which runs the validator and parses its output. The output is then placed in a Mysql database. For each website that was checked, four pieces of information were collected:

- Whether or not a cascading style sheet was found,
- Whether or not there was a fatal error,
- The total number of errors, and
- The total number of warnings.

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[16] http://jigsaw.w3.org/css-validator/

[17] http://jigsaw.w3.org/css-validator/DOWNLOAD.html

Only the main page of each site was examined.

4.5.1 Previous Work

There is very little literature relating to the validation and use of Cascading Style Sheet. Although researchers recommend the use of the W3C CSS validation tool for website developers [201, 202], there are no previous surveys examining the use of CSS or checking the validation of CSS documents currently in use.

4.5.2 Results

The survey of Cascading Style Sheet use was performed on Alexa's top 10000 websites in October of 2006. All information from the HTML survey that was known about a website such as ranking, country of origin, and the continent and GDP PPP per capita for each country is also known for the websites in this survey. The websites in this survey came from a total of 82 distinct countries with 108 websites being unreachable or having no country specified at the time that the country data was acquired using the procedure outlined before.

Table 88 shows:

- The number of websites that had CSS,
- The number of websites with valid CSS,
- The number of websites that produced fatal errors, and
- The number of websites that had syntax errors or warnings in its CSS.

Most websites (84.1%) had Cascading Style Sheets; however only 40.2% of websites had valid Cascading Style Sheets. A total of 37.5% of websites had syntax errors its CSS document while 49.6% had syntax warnings. Only 6.6% of websites produced fatal errors while being checked by the W3C CSS Validator.

Table 88: Cascading Style Sheet Survey Results

	Number of Websites	Percentage of Websites
CSS Found	8412	84.1%
Valid	4022	40.2%
Fatal Errors	664	6.6%
Syntax Errors	3752	37.5%
Syntax Warnings	4964	49.6%

Table 89 gives the percentage of websites for which a CSS document was found, the percentage of websites with a valid CSS document, and the percentage of websites that produced a fatal error during validation for each country. All countries that comprised of less than 1% of the total number of websites were grouped into the Other category. Hong Kong, Korea, and Taiwan all have a higher percentage of websites with CSS documents as well as a higher percentage of websites with valid CSS documents. Although Japan also has a fairly high percentage of websites with CSS documents and percentage of websites with valid CSS document, it also has a very high percentage of websites that produced a fatal error during validation.

Table 89: CSS Results by Country

Country	CSS Found	Valid	Fatal
United States	82.4%	41.1%	5.8%
China	87.0%	36.1%	6.8%

Japan	89.5%	46.5%	10.6%
United Kingdom	73.3%	34.7%	3.4%
Canada	84.8%	38.5%	5.9%
Hong Kong	97.2%	60.4%	4.1%
Republic Of Korea	97.5%	58.7%	4.5%
Germany	73.9%	36.7%	6.1%
France	77.0%	36.2%	4.0%
Taiwan	94.5%	54.5%	4.2%
Netherlands	79.9%	40.2%	1.8%
Spain	76.6%	38.7%	3.2%
Other	84.6%	34.1%	11.6%

The percentage of websites with CSS, the percentage of websites with valid CSS, and the percentage of websites that produced fatal errors for each continent are shown in Table 90. Africa had the most websites that used CSS and the fewest fatal errors however the percentage of valid CSS is not overly different from other continents. Oceania had the fewest websites with CSS, the fewest valid CSS and the most fatal errors. While websites from Asia often scored low on the HTML validation, these websites are fairly average in the CSS results. South America has the highest percentage of websites with a valid CSS however these websites also have the second highest percentage of websites with fatal errors.

Table 90: CSS Results by Continent

	CSS Found	Valid	Fatal Errors
Africa	96.2%	42.3%	3.8%
Asia	89.5%	41.4%	6.8%
Europe	77.0%	36.2%	4.9%
North America	82.6%	41.0%	5.7%
Oceania	69.5%	32.9%	9.8%
South America	81.8%	45.5%	9.1%
Unknown	97.2%	27.8%	63.0%

Table 91 shows the results of Fisher's Exact Test (2-tail) for websites that had CSS documents by continent. Most of the values were found to be significantly different ($p<0.05$) which a few exceptions. These exceptions are Asia and Africa ($p<0.513$), Oceania and Europe ($p<0.139$), South America and Africa ($p<0.107$), South America and Europe ($p<0.403$), South America and North America ($p<0.880$), South America and Oceania ($p<0.097$), and the Unknown category and Africa ($p<0.583$).

Table 91: Fisher's Exact Test (2-tail) for CSS Found by Continent

	Africa	Asia	Europe	North America	Oceania	South America	Unknown
Africa	1.000	0.513	0.017	0.071	0.004	0.107	0.583
Asia		1.000	0.000	0.000	0.000	0.039	0.006
Europe			1.000	0.000	0.139	0.403	0.000
North America				1.000	0.005	0.880	0.000
Oceania					1.000	0.097	0.000
South America						1.000	0.000
Unknown							1.000

Table 92 gives the results of Fisher's Exact Test (2-tail) for websites with valid CSS documents by continent. Most of the results were not statistically significant. The few exceptions were Europe and Asia ($p<0.001$), North America and Europe ($p<0.001$), and the Unknown category and Asia ($p<0.05$), North America ($p<0.05$), and South America ($p<0.05$).

Table 92: Fisher's Exact Test (2-tail) for Valid by Continent

	Africa	Asia	Europe	North America	Oceania	South America	Unknown
Africa	1.000	1.000	0.541	1.000	0.480	0.823	0.161
Asia		1.000	0.001	0.714	0.140	0.484	0.005
Europe			1.000	0.001	0.637	0.115	0.095
North America				1.000	0.174	0.484	0.005

Oceania					1.000	0.143	0.523
South America						1.000	0.019
Unknown							1.000

Table 93 shows the results of Fisher's Exact Test (2-tail) for websites that produced fatal errors during validation by continent. Most of these results were not statistically different with the exception of the Unknown category compared to every continent ($p<0.001$), Asia and Europe ($p<0.05$), and Asia and North America ($p<0.05$).

Table 93: Fisher's Exact Test (2-tail) for Fatal Errors by Continent

	Africa	Asia	Europe	North America	Oceania	South America	Unknown
Africa	1.000	1.000	1.000	1.000	0.684	0.676	0.000
Asia		1.000	0.009	0.044	0.272	0.369	0.000
Europe			1.000	0.218	0.066	0.107	0.000
North America				1.000	0.145	0.213	0.000
Oceania					1.000	1.000	0.000
South America						1.000	0.000
Unknown							1.000

The syntax errors and warnings per website as well as the percentage of websites with syntax errors and warnings by country are shown in Table 94. All countries that represent less than 1% of the total websites are included in the Other category. Korea has far more syntax errors per website than any other nation and Korea and Germany have far more syntax warnings than any other nation. Japan has the fewest syntax errors and warnings per website.

Table 94: Syntax Errors and Warnings by Country

Country	Syntax Errors per Website	Websites with Syntax Errors	Syntax Warnings per Website	Websites with Syntax Warnings
United States	20	35.8%	218	51.7%

China	24	44.1%	97	49.4%
Japan	11	32.5%	81	47.0%
United Kingdom	21	35.6%	350	46.3%
Canada	21	41.1%	210	57.0%
Hong Kong	33	32.7%	84	40.6%
Republic Of Korea	120	34.3%	722	34.8%
Germany	24	31.7%	772	45.0%
France	31	36.8%	429	48.9%
Taiwan	27	35.8%	191	40.0%
Netherlands	20	37.8%	187	48.2%
Spain	20	35.5%	243	46.0%
Other	27	39.4%	240	49.4%

Table 95 shows the percentage of websites with errors and warnings as well as the errors and warnings per website for each continent. South America has the lowest percentage of websites with errors and warnings as well as the fewest errors and warnings per website. Africa has the highest percentage of websites with both errors and warnings, however other continents have more errors per website (Oceania) and warnings per website (Europe).

Table 95: Syntax Errors and Warnings by Continent

	Syntax Errors per Website	Websites with Syntax Errors	Syntax Warnings per Website	Websites with Syntax Warnings
Africa	31	50.0%	273	57.7%
Asia	30	41.4%	147	48.5%
Europe	22	36.3%	346	48.0%
North America	20	36.2%	216	52.1%
Oceania	32	30.5%	234	41.5%
South America	13	27.3%	95	36.4%
Unknown	5	6.5%	35	7.4%

Table 96 shows the percentage of websites that have a CSS, the percentage of websites with a valid CSS, and the percentage of websites that produced a fatal error for each GDP

PPP per capita category. There is no clear trend between any of the variables and GDP PPP per capita.

Table 96: CSS Results by GDP PPP per Capita (USD)

	CSS Found	Valid	Fatal Errors
>40000	82.3%	41.0%	5.8%
>30000	82.2%	41.5%	6.4%
>20000	90.0%	46.1%	4.0%
>10000	90.4%	35.6%	8.7%
<10000	87.1%	36.3%	6.6%
Unknown	95.4%	30.0%	52.3%

The percentage of websites with a Style Sheet, the percentage of websites with a valid Style Sheet, and the percentage of websites that produced a fatal error for each e-Readiness category are shown in Table 97. There is no clear trend between any of the variables and the e-Readiness score.

Table 97: CSS Results by e-Readiness Category

	CSS Found	Valid	Fatal Errors
8.xx	81.7%	40.7%	5.5%
7.xx	88.4%	45.7%	7.2%
6.xx	77.2%	34.6%	3.9%
5.xx	82.8%	45.5%	7.5%
4.xx	90.9%	33.2%	4.8%
3.xx	87.4%	36.2%	6.9%
Unknown	94.8%	31.0%	40.2%

The percentage of websites with errors and warnings as well as the number of errors and warnings per website for each GDP PPP per capita category are shown in Table 98. Again, there is no clear trend between any of the variables and GDP PPP per capita.

Table 98: Errors and Warnings by GDP PPP per Capita (USD)

	Syntax Errors per Website	Websites with Syntax Errors	Syntax Warnings per Website	Websites with Syntax Warnings
>40000	20	35.8%	218	51.8%
>30000	20	34.7%	248	47.1%
>20000	55	40.0%	362	44.5%
>10000	26	46.1%	207	56.6%
<10000	25	44.2%	120	50.7%
Unknown	8	13.1%	30	15.4%

Table 99 shows the number of errors and warnings per website as well as the percentage of websites with errors and warnings for each e-Readiness category. As with the GDP PPP results, there is no clear trend in the data when examined with respect to e-Readiness score.

Table 99: Errors and Warnings by e-Readiness Category

	Syntax Errors per Website	Websites with Syntax Errors	Syntax Warnings per Website	Websites with Syntax Warnings
8.xx	20	35.9%	236	50.7%
7.xx	36	35.6%	242	45.6%
6.xx	22	39.4%	299	48.0%
5.xx	26	29.9%	204	41.0%
4.xx	33	53.5%	271	63.6%
3.xx	25	44.4%	105	50.3%
Unknown	17	23.6%	120	29.3%

The number of Cascading Style Sheets found as a function of website ranking is shown in Figure 33. This graph shows an increase in the use of CSS on websites as website ranking decreases.

Figure 33: CSS Found versus Website Ranking

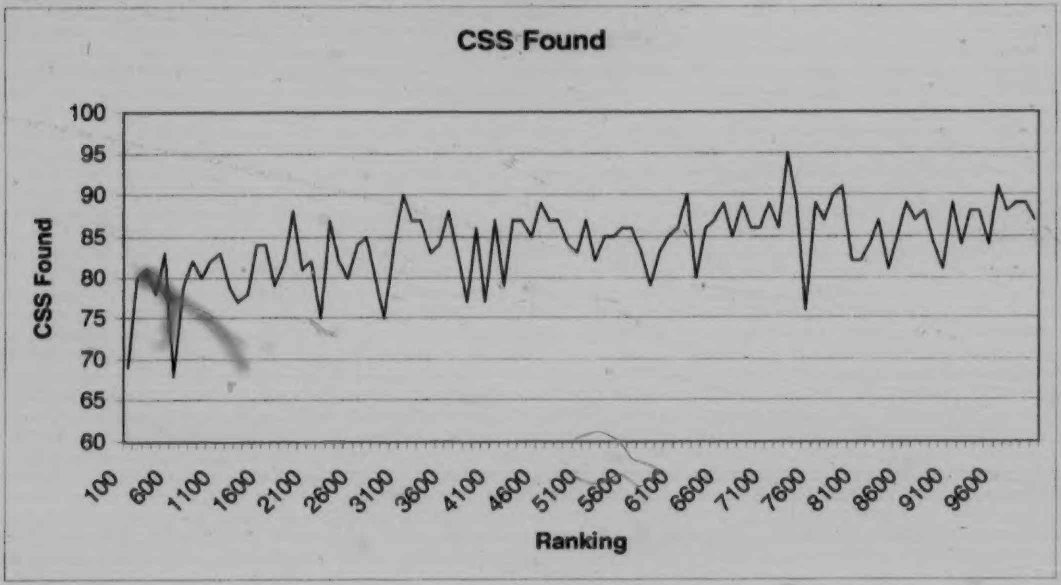

Table 100 shows the results of Spearman's correlation between website ranking and CSS Found. This relationship is statistically significant (p<0.001) however the low value of R (0.078) makes the strength of the relationship negligible.

Table 100: Spearman's Rho, R, and R^2 for CSS Found and Website Ranking

Rho	0.072	R	0.078
p	0.000	Upper	0.094
Upper	0.092	Lower	0.047
p	0.000	R^2	0.006
Lower	0.052	Upper	0.009
p	0.000	Lower	0.002

Figure 34 shows the number of websites with valid Cascading Style Sheets as a function of website ranking. Although more style sheets were found as ranking decreased, this graph shows a decrease in the number of websites with valid style sheets as ranking decreases.

Figure 34: Valid CSS versus Website Ranking

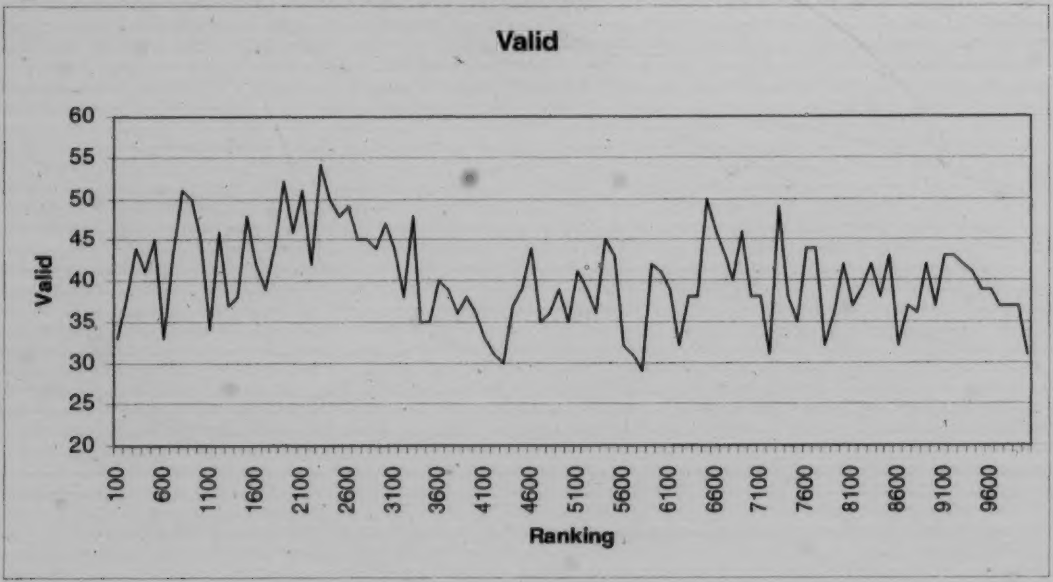

Table 101 shows the results of Spearman's correlation between website ranking and the number of valid CSS found. The relationship is statistically significant (p<0.001) however the strength of the relationship is negligible (R=-0.031).

Table 101: Spearman's Rho, R, and R^2 for Valid CSS and Website Ranking

Rho	-0.034	R	-0.031
p	0.001	Upper	-0.016
Upper	-0.014	Lower	-0.063
p	0.110	R^2	0.001
Lower	-0.054	Upper	0.000
p	0.000	Lower	0.004

Figure 35 shows the number of websites that produced fatal errors as a function of website ranking. This graph shows an anomaly of no fatal errors for the first 3000 websites. This explains some of the results seen in Figure 34. For the first 3000 websites where there are no fatal errors there are more valid style sheets. After this point the number of valid style sheets found drops as the number of fatal errors increases.

Figure 35: Fatal Errors versus Website Ranking

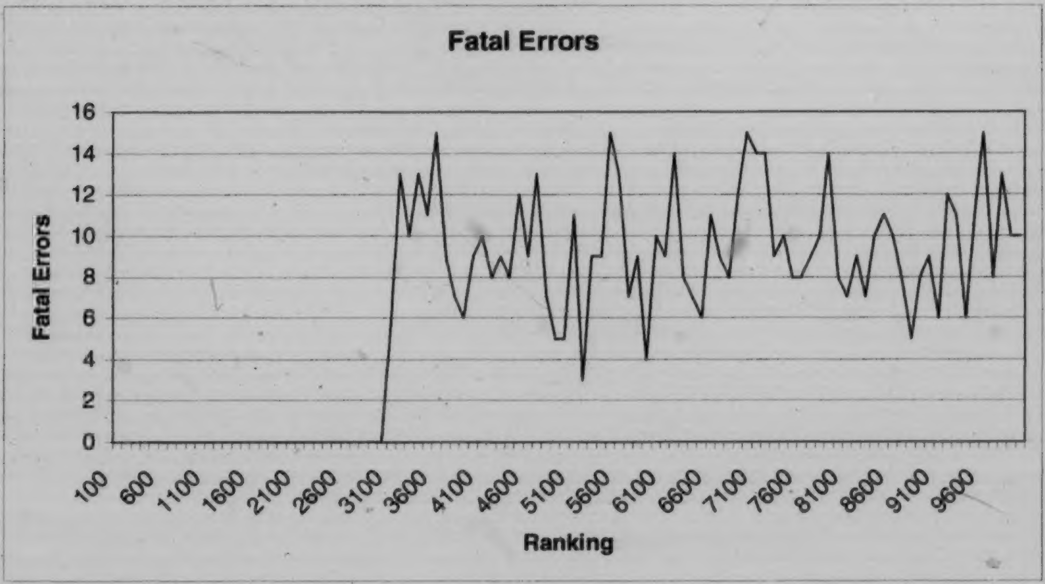

Table 102 shows the results of Spearman's correlation between website ranking and the number of websites that produced fatal errors. This relationship is statistically significant ($p<0.001$) and the strength of the relationship is weak with R being 0.141. The relationship accounts for 2.0% of the variance seen.

Table 102: Spearman's Rho, R, and R^2 for Fatal Errors and Website Ranking

Rho	0.141	R	0.141

p	0.000	Upper	0.172
Upper	0.160	Lower	0.125
p	0.000	R^2	0.020
Lower	0.122	Upper	0.030
p	0.000	Lower	0.016

Figure 36 shows the graph of the number of fatal errors per 100 websites as a function of website ranking with the first zero data points taken out. No obvious trend is seen in this graph.

Figure 36: Fatal Errors versus Website Ranking for non-zero data

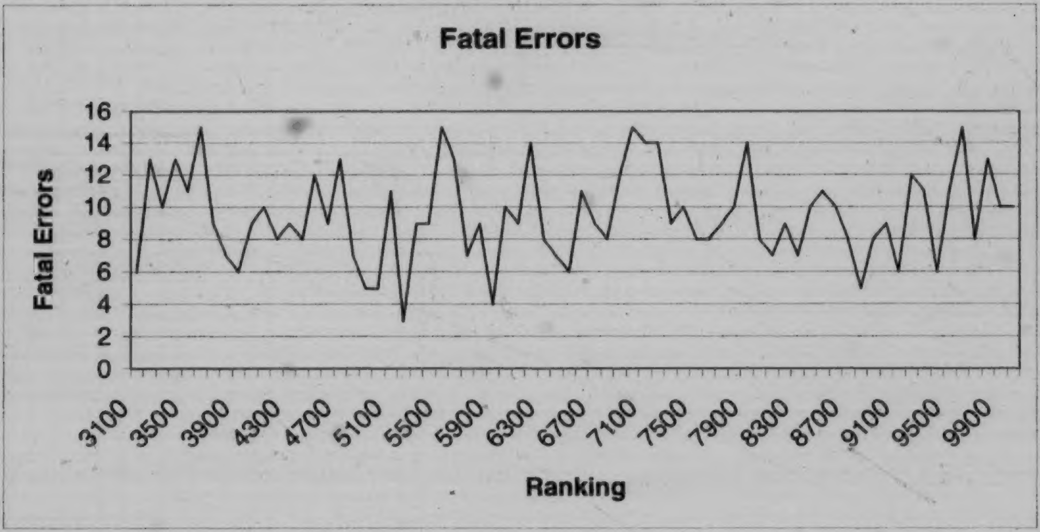

Table 103 shows the results of Spearman's correlation between website ranking and the number of websites that produce fatal errors. The first 3000 websites that produced zero fatal errors were removed from this analysis. The relationship was not found to be statistically significant ($p<0.769$).

Table 103: Spearman's Rho, R, and R^2 for Fatal Errors with out zero data and Website Ranking

Rho	0.004	R	0.000
p	0.769	Upper	0.031
Upper	0.023	Lower	-0.016
p	0.002	R^2	0.000
Lower	-0.016	Upper	0.001
P	0.110	Lower	0.000

Figure 37 shows the number of websites with errors and warnings as a function of ranking. The top line represents websites with warnings while the bottom line represents websites with errors. No relationships between website ranking and the number of websites with errors and warnings is seen in this graph.

Figure 37: Websites with Syntax Errors and Warnings versus Website Ranking

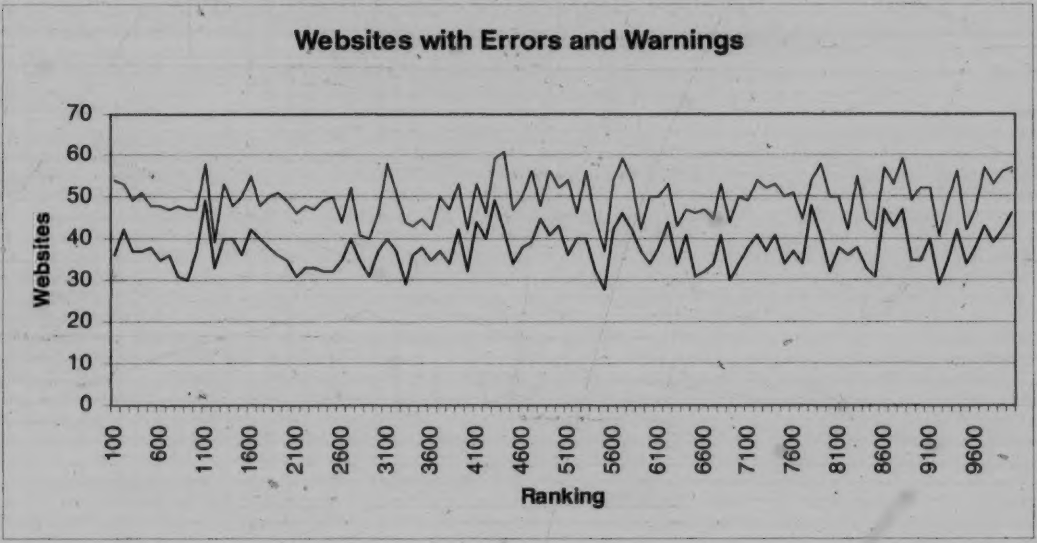

Figure 38 shows the results of subtracting the number of websites with errors from the number of websites with warnings, which are the two curves in Figure 37. The resulting graph is fairly jagged reflecting the jagged nature of the original curves however there is little variation. This suggests that the original two curves tend to move together.

Figure 38: Difference between Websites with Syntax Errors and Warnings

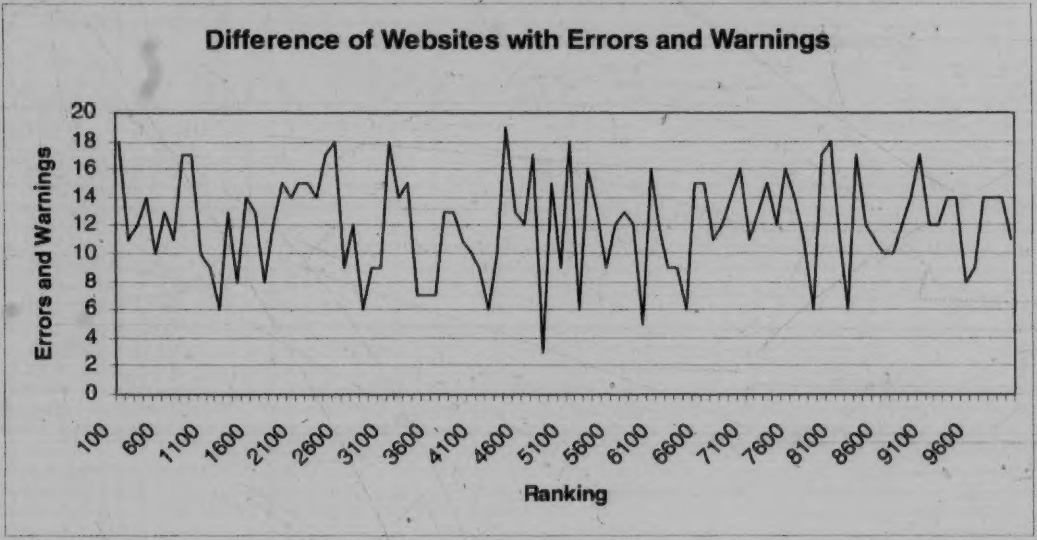

Table 104 shows the results of Spearman's correlation between website ranking and websites with syntax errors or syntax warnings. Both of these relationships were found to not be statistically significant.

Table 104: Spearman's Rho, R, and R^2 for Websites with Syntax Errors and Warnings and Website Ranking

Websites with Errors	Rho	0.014	R	0.016
	p	0.157	Upper	0.031
	Upper	0.034	Lower	0.000
	p	0.002	R^2	0.000
	Lower	-0.005	Upper	0.001
	p	1.000	Lower	0.000
Websites with Warnings	Rho	0.015	R	0.016
	p	0.136	Upper	0.031
	Upper	0.035	Lower	0.000

	p	0.002	R^2	0.000
	Lower	-0.005	Upper	0.001
	p	1.000	Lower	0.000

Figure 39 shows the number of errors and warnings per website as a function of website ranking. Again, the top line represents warnings per website while the bottom line represents errors per website. As with the graph in Figure 37, no relationship is seen between the number of errors or warnings per website and website ranking.

Figure 39: Syntax Errors and Warnings per Website versus Website Ranking

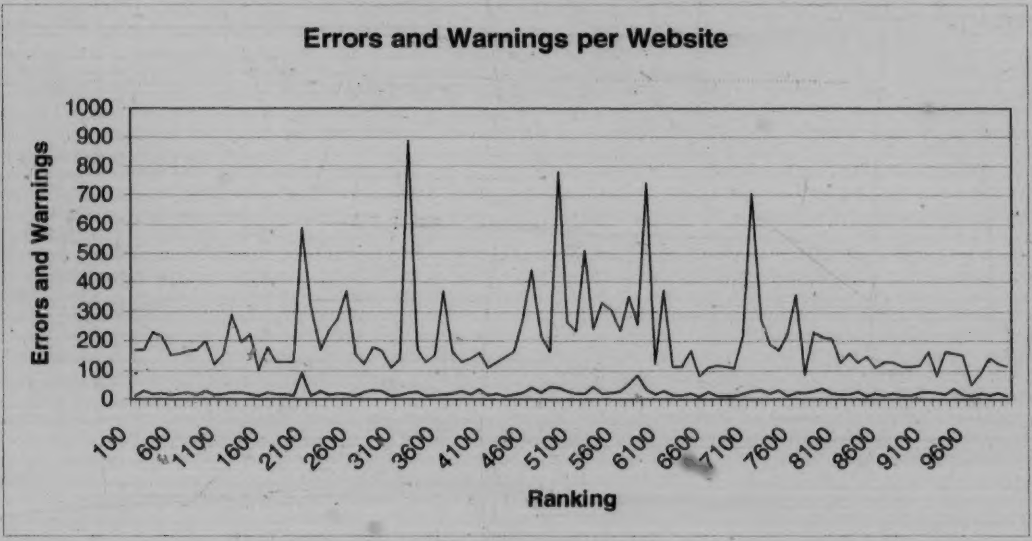

Figure 40 shows the results of subtracting the errors per website curve from the warnings per website curve in Figure 39. The result looks very similar to the warnings per website curve as there are far more warnings per website than errors per website.

Figure 40: Difference between Syntax Errors and Warnings per Website

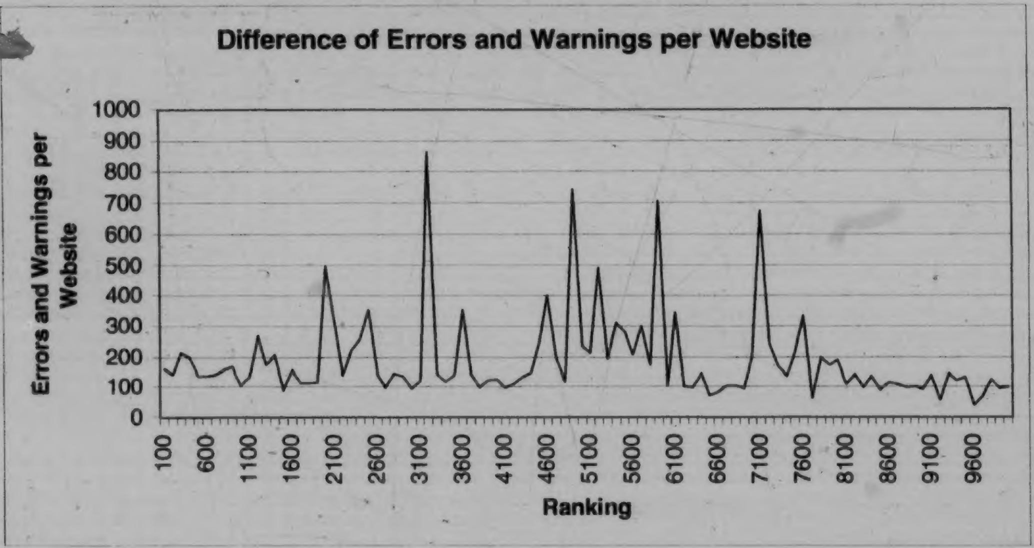

Table 105 shows the results of Spearman's correlation between website ranking and the number or syntax errors or warnings per website. Both of these relationships were found to not be statistically significant.

Table 105: Spearman's Rho, R, and R^2 for Syntax Errors and Warnings per Website and Website Ranking

Errors	Rho	0.015	R	0.016
	p	0.134	Upper	0.031
	Upper	0.035	Lower	0.000
	p	0.023	R^2	0.000
	Lower	-0.005	Upper	0.001
	p	1.000	Lower	0.000
Warnings	Rho	0.008	R	0.016
	p	0.427	Upper	0.031
	Upper	0.028	Lower	-0.016
	p	0.023	R^2	0.000
	Lower	-0.012	Upper	0.001
	p	0.110	Lower	0.000

4.6 Link Survey

The W3C Link Checker[18] was used to perform this survey. It was downloaded from CPAN[19]. A wrapper was built around the Link Checker in order to automate it. The wrapper ran the link code and placed the output into a Mysql database. The total links checked for each type of return code was saved. Links were only checked one page deep. All return coded except for the robot code were taken from the W3C documentation[20].

Table 106: HTTP return codes

Return Code	Type	Description
Robot		A robot.txt file disallowed checking the link
100	Informational	Continue
101	Informational	Switching Protocols
200	Successful	OK
201	Successful	Created
202	Successful	Accepted
203	Successful	Non-Authoritative Information
204	Successful	No Content
205	Successful	Reset Content
206	Successful	Partial Content
300	Redirection	Multiple Choices
301	Redirection	Moved Permanently
302	Redirection	Found
303	Redirection	See Other
304	Redirection	Not Modified
305	Redirection	Use Proxy
306	Redirection	(Unused)
306	Redirection	Temporary Redirect
400	Client Error	Bad Request
401	Client Error	Unauthorized

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[18] http://validator.w3.org/checklink

[19] http://search.cpan.org/dist/W3C-LinkChecker/

[20] http://www.w3.org/Protocols/rfc2616/rfc2616-sec10.html

402	Client Error	Payment Required
403	Client Error	Forbidden
404	Client Error	Not Found
405	Client Error	Method Not Allowed
406	Client Error	Not Acceptable
407	Client Error	Proxy Authentication Required
408	Client Error	Request Timeout
409	Client Error	Conflict
410	Client Error	Gone
411	Client Error	Length Required
412	Client Error	Precondition Failed
413	Client Error	Request Entity Too Large
414	Client Error	Request-URI Too Long
415	Client Error	Unsupported Media Type
416	Client Error	Requested Range Not Satisfiable
417	Client Error	Expectation Failed
500	Server Error	Internal Server Error
501	Server Error	Not Implemented
502	Server Error	Bad Gateway
503	Server Error	Service Unavailable
504	Server Error	Gateway Timeout
504	Server Error	HTTP Version Not Supported

4.6.1 Previous Work

Very little previous research could be found that examined broken links on websites. Pollach et al [192] performed a study of the functionality and accessibility of 226 environmental websites obtained from the Google Directory. The survey used WebXACT to check for broken links. Return codes for the links were not given in the study, nor were the total number of links on the websites. This study found that websites had an average of 1.33 to 3.21 broken links.

4.6.2 Results

The survey of website links was performed on Alexa's top 30000 websites in October of 2006. Only 30 000 websites were surveyed because of time and resource constrains while running the survey. All information from the HTML survey that was known about a website such as ranking, country of origin, and the continent and GDP PPP per capita for each country is also known for the websites in this survey. The websites in this survey came from a total of 100 distinct countries with 359 websites being unreachable or having no country specified at the time that the country data was acquired from the whois database.

Not all HTTP return codes from Table 106 were found while checking links in this survey. Table 107 shows the number of websites that had each type of return code that was found. Note that a single website may have many links which may represent many different return codes. There were no Informational return codes. Most of the Successful return codes were 200 OK, most of the Redirection return codes were 302 Found, most of the Client Error return codes were 404 Not Found, and the Server Error return codes were mostly split between 500 Internal Server Error and 501 Not Implemented. The Robot return code refers to the number of links that were not checked because of robot.txt exclusion rules. What is surprising from these results is the large number of websites having Client Error return codes. Also troubling is the large numbers of websites with Server Error return codes. Note that the number of websites in the second column cannot be added together as one website may have links that return all types of return codes shown.

Table 107: Number of websites for each return code found

Return Code Type	Number of Websites	Percentage of Websites
Robot	8585	42.9%
R200	17880	89.4%
R201	1	0.0%
R202	2	0.0%
R204	22	0.1%
R205	1	0.0%
R300	8	0.0%
R301	7668	38.3%
R302	12127	60.6%
R303	286	1.4%
R304	28	0.1%
R307	33	0.2%
R400	1014	5.1%
R401	294	1.5%
R402	2	0.0%
R403	2463	12.3%
R404	4024	20.1%
R405	421	2.1%
R406	42	0.2%
R408	5	0.0%
R410	7	0.0%
R412	3	0.0%
R500	4465	22.3%
R501	5764	28.8%
R502	48	0.2%
R503	130	0.7%
R504	13	0.1%

Table 108 shows the number of links found that return each type of HTTP return code as well as the average number of each type of link per website surveyed. Receiving a redirection HTTP response code from a web server can be caused by leaving off the trailing '/' on a link so the large number of redirect links is not surprising. This study found a mean of 6.7 broken links (Client or Server Error) per website with a standard deviation of 28.4 broken links per website. This is in contrast to 1.33 to 3.21 broken links per website found by Pollach et al [192]. However, Pollach et al's study examined

226 environmental websites while this study has examined general Internet sites based on popularity. It is possible that the environmental sites are simpler (less links) then general Internet websites or that the environmental sites are more closely monitored for correctness then the general Internet websites.

Table 108: Number of links found for each type of return code

Type of Return Code	Number of Links	Links per Site
Successful (2xx)	1981004	99
Redirection (3xx)	247850	12
Client Error (4xx)	72460	4
Server Error (5xx)	62118	3

Table 109 shows the number of links for each return code category per websites by country. A large variation is seen in the number of links between countries in each return code category. China has far more links per website that returned Client Error return codes than other nations. China also have a larger number of total links per website, while Taiwan has the fewest total links per website. These differences will be further examined in the by continent, GDP, and e-Readiness analysis.

Table 109: Links per Website by Country

	Robot	Successful	Redirection	Client Error	Server Error	Total
United States	5	90	15	2	2	114
China	2	158	11	12	5	188
Japan	3	89	6	2	3	102
United Kingdom	4	80	9	2	3	98
Canada	4	68	10	1	2	84
Germany	7	86	10	2	4	109
Republic Of Korea	5	75	9	1	7	97
France	4	84	12	1	4	104
Hong Kong	2	75	10	1	2	90
Netherlands	5	112	12	2	4	135
Taiwan	2	58	9	1	2	72
Spain	5	95	8	2	3	112

Other	4	79	13	1	3	100

Table 110 shows the results of Fisher's Exact Test (2-tailed) to determine if there are relationships between the average number of broken and working links per website between different countries. Working links consisted of links with returned Successful or Redirection HTTP responses and broken links were links that returned Client Error or Server Error HTTP responses. No statistically significant results were found between any of the nations below.

Table 110: Fisher's Exact Test (2-tailed) for Broken Links vs. Working Links by Country

	United States	China	Japan	United Kingdom	Canada	Germany	Republic Of Korea	France	Hong Kong	Netherlands	Taiwan	Spain	Other
United States	1.000	0.101	1.000	0.736	1.000	0.528	0.231	0.741	1.000	1.000	1.000	1.000	1.000
China		1.000	0.154	0.349	0.203	0.373	1.000	0.250	0.134	0.186	0.296	0.102	0.156
Japan			1.000	0.743	1.000	0.748	0.240	1.000	1.000	1.000	1.000	1.000	1.000
United Kingdom				1.000	0.728	1.000	0.406	1.000	0.721	1.000	1.000	0.737	0.746
Canada					1.000	0.733	0.226	1.000	1.000	1.000	1.000	1.000	1.000
Germany						1.000	0.582	1.000	0.507	0.768	0.740	0.530	0.749
Republic Of Korea							1.000	0.393	0.213	0.267	0.354	0.232	0.245

France								1.000	0.725	1.000	1.000	0.742	1.000
Hong Kong									1.000	0.742	1.000	1.000	1.000
Netherlands										1.000	1.000	1.000	1.000
Taiwan											1.000	1.000	1.000
Spain												1.000	1.000
Other													1.000

Table 111 shows the average number of links per website found of each return code type for each continent. The continents of Asia and Oceania have the highest number of links with errors while Africa and South America have the lowest number of links with errors. These continents also have the highest and lowest respectively total number of links. Oceania has the highest links with errors to total number of links ratio.

Table 111: Links per Website by Continent

	Robot	Successful	Redirection	Client Error	Server Error	Total
Africa	2	67	11	2	4	86
Asia	2	124	10	7	4	147
Europe	5	91	13	2	3	113
North America	5	89	14	2	2	112
Oceania	7	85	18	1	3	115
South America	2	64	6	2	5	80
Unknown	1	18	2	0	0	22

Table 112 shows the results of Fisher's Exact Test (2-tail) for the average number of broken links and working links per website between different continents. No statistically significant relationships were found.

Table 112: Fisher's Exact Test (2-tailed) for Broken Links vs. Working Links by Continent

	Africa	Asia	Europe	North America	Oceania	South America	Unknown
Africa	1.000	1.000	0.538	0.340	0.340	0.776	1.000
Asia		1.000	0.315	0.193	0.193	1.000	1.000
Europe			1.000	1.000	1.000	0.245	1.000
North America				1.000	1.000	0.207	1.000
Oceania					1.000	0.207	1.000
South America						1.000	1.000
Unknown							1.000

Table 113 shows the number of links per website of each return code type for each GDP PPP per capita category. As the GDP PPP per capita increases, the number of total links per website decreases, with the exception of the category of greater than $40000 USD. The United States dominates this category and it has been found when examining other data (see **Table 38**) that this nation is an anomaly. Also of interest is the much larger number of Client Errors found in the less than $10000 USD category, which is dominated by websites from China.

Table 113: Links per Website by GDP PPP per Capita (USD)

	Robot	Successful	Redirection	Client Error	Server Error	Total
>40000	5	91	15	2	2	115
>30000	4	84	10	2	3	102
>20000	3	78	10	1	4	96
>10000	4	98	17	1	3	123
<10000	2	146	11	11	5	175
Unknown	2	24	4	0	1	31

Table 114 shows the results of Fisher's Exact Test (2-tailed) for the number of broken and working links per websites for each GDP category. No statistically significant relationships were found.

Table 114: Fisher's Exact Test (2-tailed) for Broken Links vs. Working Links by GDP PPP per Capita Category

	>40000	>30000	>20000	>10000	<10000	Unknown
>40000	1.000	1.000	0.735	1.000	0.096	1.000
>30000		1.000	0.742	1.000	0.149	1.000
>20000			1.000	0.750	0.343	1.000
>10000				1.000	0.111	1.000
<10000					1.000	0.477
Unknown						1.000

The number of links per website of each return code type for each e-Readiness category is shown in Table 115. The same trend that was seen in the GDP PPP analysis is not present here. This may be due to the fact that although the GDP PPP and e-Readiness data is linearly related, individual nations' positions on these two ratings do not exactly match up. The 2.xx category is an anomaly in this data with far fewer links (51 links per site) than any other category.

Table 115: Links per Website by e-Readiness Category

	Robot	Successful	Redirection	Client Error	Server Error	Total
8.xx	5	89	14	2	2	112
7.xx	3	83	8	1	3	99
6.xx	4	92	14	1	3	114
5.xx	3	80	19	1	4	108
4.xx	2	89	8	2	4	106
3.xx	2	154	11	11	5	184
2.xx	0	62	3	0	0	65
Unknown	2	36	5	1	1	44

Table 116 shows the results for Fisher's Exact Test (2-tailed) for the average number of broken and working links per website in each e-Readiness category. For most of the results, no statistically significant relationship was found. The exceptions were between the 2.xx and 4.xx categories ($p < 0.05$), and the 2.xx and 3.xx categories ($p < 0.01$).

Table 116: Fisher's Exact Test (2-tailed) for Broken Links vs. Working Links by e-Readiness Category

	8.xx	7.xx	6.xx	5.xx	4.xx	3.xx	2.xx	Unknown
8.xx	1.000	0.739	1.000	0.747	0.371	0.149	0.299	1.000
7.xx		1.000	0.737	1.000	0.769	0.345	0.083	1.000
6.xx			1.000	0.743	0.364	0.100	0.298	0.674
5.xx				1.000	0.768	0.247	0.158	1.000
4.xx					1.000	0.654	0.044	1.000
3.xx						1.000	0.008	0.537
2.xx							1.000	0.156
Unknown								1.000

The total number of links found per website as a function of website ranking is shown in Figure 41. There are two things of interest shown in this graph. The first is a several large jumps in the number of links found for websites ranked around 8000 and 18000. There is no explanation for why this anomaly exists. The second point of interest is that there is an overall downwards trend in the total number of links per website as the ranking decreases. This suggests that more popular websites have more links.

Figure 41: Total Number of Links per Site versus Website Ranking

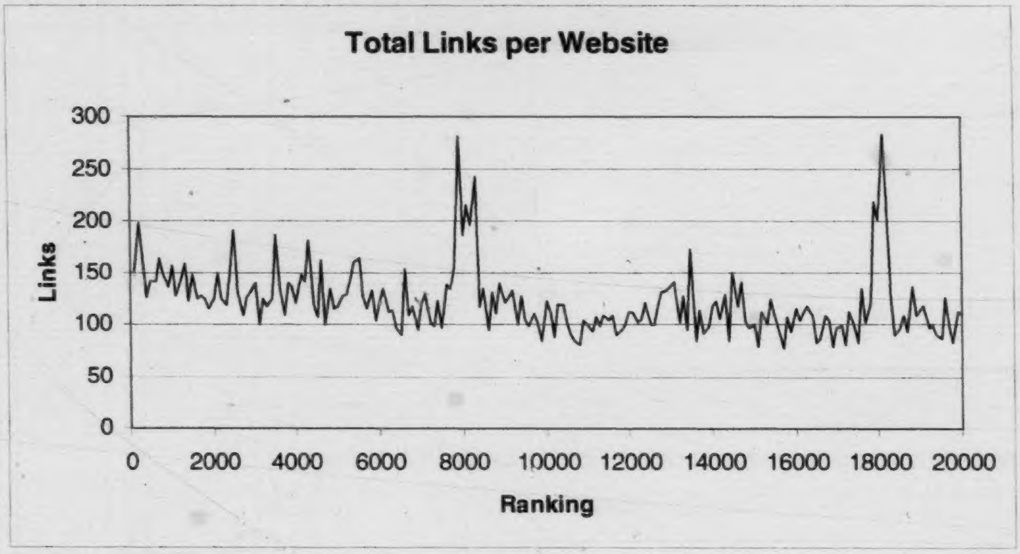

Table 117 shows the results of Spearman's correlation between the total number of links found per website and website ranking. The relationship was found to be statistically significant ($p<0.01$) however strength of the relationship is negligible, accounting for only 0.9% of the variance seen.

Table 117: Spearman's Rho, R, and R^2 for Total Links per Website and Website Ranking

Rho	-0.061	R	-0.094
p	0.000	Upper	-0.063
Upper	-0.041	Lower	-0.125
p	0.000	R^2	0.009
Lower	-0.081	Upper	0.004
P	0.000	Lower	0.016

Figure 42 shows the number of working links per website as a function of ranking. Working links are links that are successful or redirect. The same trends can be seen here as was seen when examining the total number of links per website. The number of working links per website decreases with the popularity of the.

Figure 42: Working Links per Website versus Website Ranking

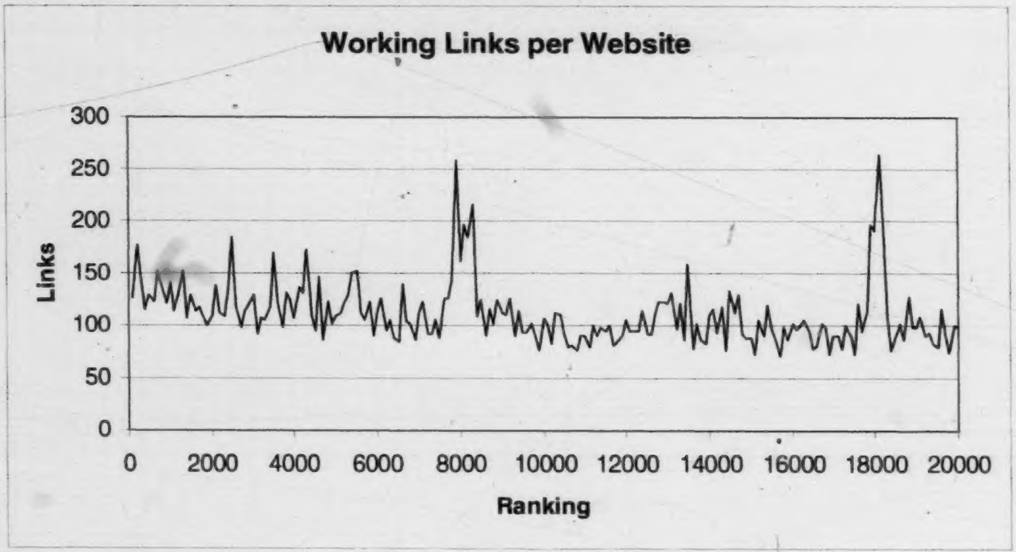

Table 118 shows the results of Spearman's correlation between the number of working links per website and website ranking. The relationship is statistically significant ($p<0.01$) however the strength of the relationship is negligible.

Table 118: Spearman's Rho, R, and R^2 for Working Links per Website and Website Ranking

Rho	-0.059	R	-0.094
p	0.000	Upper	-0.063
Upper	-0.039	Lower	-0.125
p	0.000	R^2	0.009
Lower	-0.079	Upper	0.004
p	0.000	Lower	0.016

The number of broken links found per website as a function of website ranking is shown in Figure 43. Broken links are links which either had a client or server error. The number of broken links per website decreases with website popularity.

Figure 43: Broken Links per Website versus Website Ranking

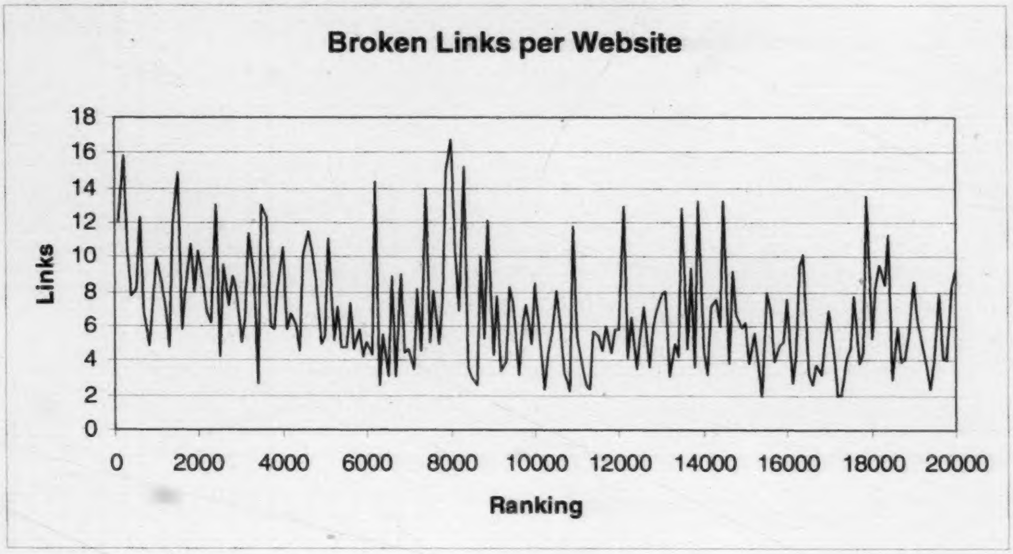

Table 119 shows the results of Spearman's correlation between the number of broken links per website and website ranking. Again, the results are statistically significant ($p<0.01$) however the strength of the relationship is negligible.

Table 119: Spearman's Rho, R, and R^2 for Broken Links per Website and Website Ranking

Rho	-0.058	R	-0.094
p	0.000	Upper	-0.063
Upper	-0.038	Lower	-0.125
p	0.000	R^2	0.009
Lower	-0.078	Upper	0.004
p	0.000	Lower	0.016

4.7 Analysis of Surveys

Table 120 shows Phi and Cramer's V for valid html, valid CSS documents, and no broken links. These variables are all dichotomous. The relationship between Valid CSS documents on websites and websites with valid HTML was found to be not statistically significant with p<0.749 for both Phi and Cramer's V. Although the relationship between having no broken links and valid HTML on a website was found to be statistically significant (p<0.01), the values for both Phi and Cramer's V (0.074) are low enough that the strength of the association between these variables is negligible. The relationship between a website having no broken links and a valid CSS document was found to be statistically significant (p<0.01) with the values of Phi and Cramer's V both being 0.229. This is a moderately strong association.

Table 120: Phi and Cramer's V correlation for the validity of websites

		Valid HTML	Valid CSS	No Broken Links
Valid HTML	Phi		-0.003	0.074
	Approx. Sig.		0.749	0.000
	Cramer's V		0.003	0.074
	Approx. Sig.		0.749	0.000
Valid CSS	Phi	-0.003		0.229
	Approx. Sig.	0.749		0.000
	Cramer's V	0.003		0.229
	Approx. Sig.	0.749		0.000
No Broken Links	Phi	0.074	0.229	
	Approx. Sig.	0.000	0.000	
	Cramer's V	0.074	0.229	
	Approx. Sig.	0.000	0.000	

Table 121 shows Phi and Cramer's V for invalid html, invalid CSS documents, and broken links. These variables are all dichotomous. All relationships examined Table 121 were found to be statistically significant with p<0.01. The relationship between a website having broken links and invalid HTML was negligible with Phi and Cramer's V being 0.074. The relationship between an invalid CSS document and invalid HTML was found to be weak with Phi and Cramer's V being 0.112. The relationship between an invalid CSS document and broken links was also found to be weak with Phi and Cramer's V being 0.161.

Table 121: Phi and Cramer's V correlation for the invalidity of websites

		Invalid HTML	Invalid CSS	Broken Links
Invalid HTML	Phi		0.112	0.074
	Approx. Sig.		0.000	0.000
	Cramer's V		0.112	0.074
	Approx. Sig.		0.000	0.000
Invalid CSS	Phi	0.112		0.161
	Approx. Sig.	0.000		0.000
	Cramer's V	0.112		0.161
	Approx. Sig.	0.000		0.000
Broken Links	Phi	0.074	0.161	
	Approx. Sig.	0.000	0.000	
	Cramer's V	0.074	0.161	
	Approx. Sig.	0.000	0.000	

Table 122 shows Spearman's correlation coefficients for the number of warnings, errors, and the number of working, broken, and total links found on each website as well as the confidence intervals for each test. The confidence intervals for each value of Rho were calculated using the formulas given in [197]. Spearman's correlation was used because these variables were deemed to be non-parametric and were rescaled (subtracted the minimum and divided by the range). Note that values for Rho are not given for the correlation between the total number of links and the number of broken or working links.

This is because the total number of links is calculated using the number of broken and working links. All correlations are statistically significant at $p < 0.05$ (2-tailed).

Table 122: Spearman's Rho for errors and links on websites

		HTML Errors	HTML Warnings	CSS Errors	CSS Warnings	Good Links	Broken Links	Total Links
HTML Errors	Rho	1.000	0.740	0.187	0.209	0.303	0.231	0.310
	p	-	0.000	0.000	0.000	0.000	0.000	0.000
	Upper	-	0.749	0.206	0.228	0.321	0.250	0.328
	p	-	0.000	0.000	0.000	0.000	0.000	0.000
	Lower	-	0.730	0.168	0.190	0.285	0.212	0.292
	p	-	0.000	0.000	0.000	0.000	0.000	0.000
HTML Warnings	Rho		1.000	0.085	0.092	0.305	0.231	0.315
	p		-	0.000	0.000	0.000	0.000	0.000
	Upper		-	0.105	0.112	0.323	0.250	0.333
	p		-	0.000	0.000	0.000	0.000	0.000
	Lower		-	0.065	0.072	0.287	0.212	0.297
	p		-	0.000	0.000	0.000	0.000	0.000
CSS Errors	Rho			1.000	0.771	0.232	0.207	0.242
	p			-	0.000	0.000	0.000	0.000
	Upper			-	0.779	0.251	0.226	0.261
	p			-	0.000	0.000	0.000	0.000
	Lower			-	0.762	0.213	0.188	0.223
	p			-	0.000	0.000	0.000	0.000
CSS Warnings	Rho				1.000	0.221	0.173	0.231
	p				-	0.000	0.000	0.000
	Upper				-	0.240	0.192	0.250
	p				-	0.000	0.000	0.000
	Lower				-	0.202	0.154	0.212
	p				-	0.000	0.000	0.000
Good Links	Rho					1.000	0.580	-
	p					-	0.000	-
	Upper					-	0.594	-
	p					-	0.000	-
	Lower					-	0.566	-
	p					-	0.000	-
Broken Links	Rho						1.000	-
	p						-	-
	Upper						-	-
	p						-	-
	Lower						-	-

	p						-	-
Total Links	Rho							1.000
	p							-
	Upper							-
	p							-
	Lower							-
	p							-

Effect sizes were calculated from the Spearman's Rho values above using the table given in [198]. The values for R and R^2 are shown in Table 123. A rule for interpreting the strength of the correlations is given by Cohen where 0.1 is a weak correlation, 0.3 is a moderate correlation, and 0.5 is a strong correlation [199, 200]. According to this interpretation, the only correlations which indicates a strong relationship is between HTML warnings and errors on a website, and between CSS warnings and errors in a CSS document. The correlation between the number of broken links on a website and the number of working links on a website is also strong. The correlations between HTML error and the number of all types of links, as well as between HTML warnings and the number of all types of links are both moderately strong. All other correlations are weak. The R^2 values represent the percentage of variance shared by two variables. In this table we can see that the variables that had a strong correlation share between 57.8% and 62.4% of their variance, variables that had a moderate correlation share between 10.5% and 25.9% of their variance, and variables that had a weak correlation share between 0.9% and 8.6% of their variance.

Table 123: R and R^2 values for errors and links on websites

		HTML Errors	HTML Warnings	CSS Errors	CSS Warnings	Good Links	Broken Links	Total Links
HTML Errors	R	1.000	0.760	0.203	0.218	0.457	0.353	0.468
	Upper	-	0.760	0.218	0.233	0.482	0.383	0.495

	Lower	-	0.750	0.172	0.203	0.440	0.324	0.440
	R^2	1.000	0.578	0.041	0.048	0.209	0.125	0.219
	Upper	-	0.578	0.048	0.054	0.232	0.147	0.245
	Lower	-	0.563	0.030	0.041	0.194	0.105	0.194
HTML Warnings	R		1.000	0.094	0.094	0.468	0.353	0.482
	Upper		-	0.110	0.110	0.482	0.383	0.495
	Lower		-	0.063	0.078	0.440	0.324	0.454
	R^2		1.000	0.009	0.009	0.219	0.125	0.232
	Upper		-	0.012	0.012	0.232	0.147	0.245
	Lower		-	0.004	0.006	0.194	0.105	0.206
CSS Errors	R			1.000	0.790	0.353	0.324	0.368
	Upper			-	0.790	0.383	0.353	0.397
	Lower			-	0.780	0.324	0.294	0.339
	R^2			1.000	0.624	0.125	0.105	0.135
	Upper			-	0.624	0.147	0.125	0.158
	Lower			-	0.608	0.105	0.086	0.115
CSS Warnings	R				1.000	0.339	0.264	0.353
	Upper				-	0.368	0.294	0.383
	Lower				-	0.309	0.233	0.324
	R^2				1.000	0.115	0.070	0.125
	Upper				-	0.135	0.086	0.147
	Lower				-	0.095	0.054	0.105
Good Links	R					1.000	0.790	-
	Upper					-	0.800	-
	Lower					-	0.780	-
	R^2					1.000	0.624	-
	Upper					-	0.640	-
	Lower					-	0.608	-
Broken Links	R						1.000	-
	Upper						-	-
	Lower						-	-
	R^2						1.000	-
	Upper						-	-
	Lower						-	-
Total Links	R							1.000
	Upper							-
	Lower							-
	R^2							1.000
	Upper							-
	Lower							-

A moderate relationships was found between a website having a valid CSS document and no broken links as well as a weak relationship between a website having an invalid CSS document and containing broken links. This is in contrast to the lack of a meaningful relationship between a website having valid HTML and no broken links as well as a website having invalid HTML and containing broken links. This is a surprising result as it was expected that if website administrators take time to create valid HTML on their site, they would also insure that there were no broken links. This may be an indicator that once websites are created they are not being maintained. It was also surprising that there was no relationship between websites with a valid CSS document and valid HTML and only a weak relationship between websites with an invalid CSS document and invalid HTML. Note that not all websites contained a CSS document.

A weak correlation between the number of CSS errors and warnings and the number of good, broken, and total links was found. Additionally, a moderate correlation was found between the number of HTML errors and warnings and the number of good, broken, and total links. This could indicate that website size plays a part in the number of errors and warnings found, as large websites would be also more likely to have more links. Larger projects of any kind are more likely to have "bugs", in this case HTML and CSS errors and warnings. A weak correlation was also found between the number of HTML errors and warnings and the number of CSS errors and warnings. This indicates that these two types of errors and warnings do tend to occur together.

A strong correlation was found between the number of HTML errors and HTML warnings on a website. This indicates that if there is one type of problem with the HTML on a website, there is likely to be other problems as well. An identical trend is seen between the number of CSS errors and CSS warnings.

4.8 Discussion

This chapter examined the results of three surveys examining website quality. The first survey validated the HTML on Alexa's top 100,000 websites, the second survey validated Cascading Style Sheets on Alexa's top 10,000 websites, and the third survey checked links on Alexa's top 20,000 websites. An exploratory analysis was then performed on this data. The data was examined based on three sets of criteria; the continent that the website was from, the GDP PPP per capita category that the nation was in where the website operated, the e-Readiness score for the nation where the websites operated, and the ranking of the website from Alexa's list.

In general terms these surveys found some startling results. The general quality of websites was found to be very poor. It was found that only 3.0% of websites had valid HTML while a higher percentage (40.2%) had a valid style sheet. Websites were found to have an average of 6.7 broken links per site.

When the data was examined with respect to Alexa's ranking it was found that there was a general decrease in website quality as the ranking of the website decreased. An increased number of fatal errors were found with the HTML validator as well as an increased number of invalid or missing character sets and document types. The number of websites with valid HTML also decreased as the ranking of the websites decreases. The survey of Cascading Style Sheets found an increased number of fatal errors and a decreased number of valid style sheets with decreased ranking. The survey of links found a decrease in the total number of links with decreased ranking which suggests that less popular websites are smaller in size. Upon examining these results using Spearman's correlation is was found that although there were statistically significant, the strength of the relationship was very low with R less than 0.1 in most cases.

No general conclusions were found when examining the data with respect the continent of GDP PPP per capita, however a few interesting points were seen with respect to the economic analysis. A decreased number of websites with valid HTML was found with decreased GDP PPP per capita. However websites from the United States proved to be an exception to this trend, having fewer websites with valid HTML then other nations within that GDP PPP per capita category. As e-Readiness scores and GDP PPP for the countries are linearly related (higher GDP PPP corresponds to higher e-Readiness score), similar results were seen in the e-Readiness analysis.

When examining all three surveys together it was found that high numbers of HTML errors and warnings corresponded to high numbers of CSS errors and warnings. Websites that had poorly maintained or constructed HTML or CSS tended to be poorly maintained across the board. Another interesting result of this analysis was that websites with higher numbers of CSS or HMTL errors and warnings tended to have a higher number of total links. This suggests that larger websites are more likely to have more errors and warnings while being validated.

If 97% of all websites have HTML errors then it may be questioned why users do not see these errors? This question has two answers. The first is that users may see many of the errors but do not realize it, as only the creator of the web page knows what it is suppose to look like. Therefore errors that change slightly the layout or formatting of a website may go unnoticed. Some errors, such as a missing '>' after a tag, may cause text after that tag to simply not display in the web browser. An example of this would be forgetting the end '>' when creating a table:

<table This text would not be displayed </table>

In this case a user would have no way of knowing that content was missing from the web page. The second part of the answer is that web browsers go out of their way to display document with both HTML and CSS errors in them. Most errors, such as using attributes or tags that do not exist in the formal HTML specification, are simply ignored. For other errors such as missing required attributes (i.e. the *type* attribute from the script tag) browsers will use a default value or make an educated guess. If browsers did not display documents with errors in them, users would only be able to visit the very few websites with both valid HTML and valid CSS.

Implementation differences in web browsers, partially do to the effort made by browsers to display every website irregardless of errors, causes other problems for users. Websites may display quite differently in different browsers. Each web browser may use different default values for HTML attributes, causing changes in the appearance of web pages that use default values. For example, different browsers will use different default values for cellspacing, cellpadding, and border attributes for tables. If a website does not specifically set these values in the HTML, the tables will display differently based on the browser a user has. Another example of default values that are set by the browser are some CSS text style properties such as color and font-family. Also, many browsers offer browser specific HTML tags such as *marquee* and *bgsound* in Internet Explorer and *blink*, *multicol*, and *spacer* in Netscape. If these tags are used on a website it may not display properly or at all in other browsers. The differences in browser implementations may cause a web page that displays properly in IE 7 to not display at all in Firefox. To add to all these differences, each browser also has its own set of bugs and issues.

Web browsers also implements different web standards to different extents[21]. Neither Internet Explorer nor Firefox completely implement the current W3C standards for HTML and CSS. Firefox has the current HTML/XHTML standards 90% implemented and IE 7 has them 73% implemented while Firefox has the current CSS standards 91% implemented and IE 7 has them 56% implemented. Attributes that are not fully implemented include some of the core attributes for elements. Three attributes that are not implemented properly in popular web browsers are id, title, and lang. The attribute id, which is used to assign a unique name to an element, is not implemented properly in IE; the names are not handled in a case sensitive manner. The title attribute, which is used to give extra information about an element (often implemented as a tool tip in browsers), is not implemented properly in IE or Firefox. White space characters such as new lines, character returns, and tabs are not handled properly. Additionally Firefox truncates tool tips at a fairly small size. Internet Explorer does not provide an interface for the use of the lang attribute, which is used to specify the language of a particular element on a web page. CSS 2.1 implementation in Internet Explorer is very poor. A total of twelve of the ninety basic properties are not implemented while all the rest are only partially implemented. There may be little incentive for developers to validate their HTML and CSS documents when so many other factors affect whether or not these documents display properly. A full listing of HTML and CSS implementation in Internet Explorer 7 and Firefox 2 can be found in the Appendix in Section 7.3.

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[21] http://www.webdevout.net/browser-support-summary

There are also security and privacy concerns to users when visiting websites with a browser. Because browsers need to be overly complex in order to display all websites (with or without errors), they tend to have many security vulnerabilities. In order for a browser to be secure, it must follow a strict rule set of what is allowed and what is not allowed. Ambiguity and gray areas lead to bugs and vulnerabilities that can be exploited. Because browsers must support websites with potential errors and defects, they cannot follow a strict rule set and therefore cannot be secure. There is little users can do about these types of threats except to keep their web browser up to date. Another source of security and privacy concerns are the browser's security settings. Many trustworthy websites use technologies such as ActiveX, JavaScript, Java, and Cookies to enhance users' experience on the site. However, websites can also use these technologies to invade users' privacy or launch attacks on their computer. Users therefore need to balance functionality of the websites they visit with security and privacy concerns. Although there is a lot of debate surrounding which web browser is more secure[22], there is no concrete answer as all browsers have bugs and can be attacked.

In many cases the methods used to produce Cascading Style Sheets and HTML documents may contribute to these documents not validating. There are two methods for producing CSS and HTML documents. The first method is to use a text editor and write the documents by hand. This method is time consuming and unless the developer is an expert with CSS and HTML is may be difficult to produce documents without errors. The second method is to use a WYSIWYG (what you see is what you get) editor such as Microsoft FrontPage or Dreamweaver. With these types of editors, the developer graphically develops the web page and the editor then automatically generates the CSS and HTML code for it. However, many of these editors produce code that does not validate. For example, for a simple web page using CSS created in FrontPage, neither the HTML nor the CSS validate with W3C's validators. Errors were found with non-SGML characters being present (due to characters such as an apostrophe not being translated properly), errors because non-standard elements were used, and no document type given in the HTML, as well as the use of non-standard properties in the CSS file. This may explain in part why so few HTML and CSS documents validate.

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[22] http://www.internetnews.com/security/article.php/3492706

The large number of broken links found in this survey is a surprising result given how many free online link checkers are available. A possible explanation for this result is that most websites under go very poor maintenance procedures or are very rarely updated. However, it is also possible that even with a regular maintenance routine, the World Wide Web changes so quickly that website links are perpetually out of date. Researchers have found that a random sampling of websites on the Internet have a half-life of approximately 2 years, which suggests that the first explanation is more probable [203]. A study of web server error logs found that 93% of errors encountered were because the requested file could not be found [204]. This study found that 3.75% of all requests to the web server produced a 404 error and almost two thirds of those errors were a result of internal requests. This would suggest that problems with broken links are not a result of linking to outside resources that have moved but rather linking to internal resources and then moving them around without updating the links.

Regardless of what causes broken links on a website, its still a serious problem. Fogg performed a study to determine the what affected website credibility [181]. He found that the presence of broken links on a website had a negative influence on users' perceived credibility of, and therefore whether or not they would use, a website. His research indicated that broken links created an impression of amateurism on websites and therefore caused users to think negatively of the information or services provided by that site. The current research found that website functionality, which includes broken links, has an affect on the perceived expertise of a website as well as the perceived trustworthiness of the site, which in turn has a large affect on whether or not a user chooses to interact with the website (see Section 2).

Having HTML errors, CSS errors, and broken links on a website has negative implications for both the user's experience with the website and the overall success of the website. As a poor user experience will result in fewer visitors to a website, it should be in the best interest of website maintainers to keep their websites error free. Many tools are freely available to achieve this end however it remains a major problem on the World Wide Web.

These results suggest that there is a lot of room for improvement in website quality. Problems with the HTML or CSS on a website can create problems with the display of the website on browsers and broken links seriously degrades the usefulness of websites. These problems can affect a website's potential to engage users in e-commerce or other activities. Website operators can alleviate these concerns by ensuring their sites are compliant with W3C standards and regularly checking that links on the site are in correct working order.

5 Conclusion

5.1 Summary of the findings

In Section 2, a meta study was performed to examine what factors were found to affect a user's decision to interact with a website. The study found 18 distinct factors and 165 distinct relationships between these factors. Each factor and relationship received a ranking based on how often it was found in the examined literature. The single most important effect on a user's decision to use a websites was found to be the Usefulness of the site. This suggested that users were willing to over look other types of imperfections as long as the website provided a service that was of use to the user.

Section 3 examined the use of privacy enhancing technologies on the Internet, specifically P3P, 3rd party privacy seals, and human readable privacy policies. A total P3P adoption rate of 8.34% was found on the websites surveyed, while the e-commerce websites surveyed had an adoption rate of 21.1% and the Forbes 500 websites had an adoption rate of 3.4%. A further investigation of PETs found that 83.6% of the e-commerce websites had human readable privacy policies and 28.4% had privacy seals. This is in contrast to the Forbes 500 list, which had adoption rates of 65.1% and 2.8% respectively. These surveys found that although PETs are not widely used on the Internet, they are much more commonly seen on e-commerce websites.

Section 4 explored the topic of website correctness by examining the validity of HTML and cascading style sheets on websites as well as the number of hypertext links and broken hypertext links. These surveys were used to help understand the technical correctness of websites that are currently in use on the Internet. Generally, these surveys found that very few websites are error free. There is a lot of room for improvement.

A validation of HTML and analysis of errors was performed on Alexa's top 100,000 websites. This survey found that only 3.0% of all websites checked had valid HTML. A large number of websites (19.1%) produced a fatal error during the HTML validation process. These fatal errors included unreachable sites, incorrect or missing character sets, problems transcoding the document, and problems with an incorrect or missing document type.

A validation of style sheets and analysis of errors was performed on Alexa's top 10,000 websites. This survey found that 40.2% of websites checked had a valid CSS while 43.9% of websites had an invalid CSS. Of the websites checked, 84.1% used cascading style sheets.

Alexa's top 20,000 websites were analyzed for working and broken hypertext links. This survey found an average of 118 links per website of which 7 were broken. Of the 118 links per website found, an average of 99 links had a Successful return code, 12 links had a Redirection return code, 4 links had a Client Error return code, and 3 links had a Server Error return code.

When comparing the results of these three surveys, it was found that websites with lots of HTML errors and warnings also have lots of CSS errors and warnings. These websites also have a higher number of total links per site. One possible explanation for these results is that larger more complex websites have more errors and warnings, suggesting that the number of errors and warnings is a function of size. This would be similar to counting the number of bugs per 1000 lines of code in software projects.

5.2 Limitations of the study

Several limitations exist in this body of research. The first of these involves the meta-study. Because of the nature of this study, where prior research was examined in order to develop a framework, the results reflect current research interests as opposed to the actual decision making process of consumers. However, this limitation was minimized by only selecting previous research, which had empirical data to support its conclusions. The second limitation involved the survey of privacy enhancing technologies. Although this survey provided an accurate picture of the use of these technologies, this does not necessarily reflect the state of a user's privacy on the Internet. A website may have a privacy policy, but that policy may contain very poor privacy practices. Or worse still, a website may have a privacy policy and simply not follow it. The third limitation involves the website correctness surveys. Because many of the errors and problems found in these surveys were invisible to the user, the results do not reflect the actual user experience.

5.3 Recommendations for further research

There are several avenues that can be explored to progress the research presented in this thesis. The first is that the resulting framework, which was developed through the meta-study should be empirically verified. Web users should be surveyed to determine if this framework is valid and in what situations it is valid. Once this is done, further research should be conducted on how this framework can be practically applied to web development practices. A detailed step-by-stop plan is needed in order to develop usable and trustworthy websites based on the results of this framework.

Another HTML, CSS, and link survey should be performed in the future and the results compared to the current surveys. This would allow us to see how the validity of websites changes over time. Future surveys should also record the actual link that has been checked so that a measure can be determines for how fast links go dead, come back, or are removed completely. It would also be of use to determine which of the errors found on websites are visible to users and which are hidden.

A second survey of privacy enhancing technologies would also be of value. By comparing the new results to the results of the current survey it could be determined whether these technologies are actually being adopted on the Internet. Further research should also examine more closely the contents of privacy policies to determine if they follow good privacy practices.

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7 Appendix

7.1 Syntax Errors

There error explanations are taken directly from the W3C HTML Validation website[23].

- E0: length of name must not exceed NAMELEN (X)
- E1: length of parameter entity name must not exceed NAMELEN less the length of the PERO delimiter (X)
- E2: length of number must not exceed NAMELEN (X)
- E3: length of attribute value must not exceed LITLEN less NORMSEP (X)
- E4: a name group is not allowed in a parameter entity reference in the prolog
- E5: an entity end in a token separator must terminate an entity referenced in the same group
- E6: character X invalid: only Y and token separators allowed
- E7: a parameter separator is required after a number that is followed by a name start character
- E8: character X invalid: only Y and parameter separators allowed
- E9: an entity end in a parameter separator must terminate an entity referenced in the same declaration
- E10: an entity end is not allowed in a token separator that does not follow a token
- E11: X is not a valid token here

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[23] http://validator.w3.org/docs/errors.html

- E12: a parameter entity reference can only occur in a group where a token could occur
- E13: token X has already occurred in this group
- E14: the number of tokens in a group must not exceed GRPCNT (X)
- E15: an entity end in a literal must terminate an entity referenced in the same literal
- E16: character X invalid: only minimum data characters allowed
- E18: a parameter literal in a data tag pattern must not contain a numeric character reference to a non-SGML character
- E19: a parameter literal in a data tag pattern must not contain a numeric character reference to a function character
- E20: a name group is not allowed in a general entity reference in a start tag
- E21: a name group is not allowed in a general entity reference in the prolog
- E22: X is not a function name
- E23: X is not a character number in the document character set
- E24: parameter entity X not defined
- E25: general entity X not defined and no default entity
- E26: RNI delimiter must be followed by name start character
- E28: unterminated comment: found end of entity inside comment
- E29: comment started here
- E30: only one type of connector should be used in a single ~~group~~
- E31: X is not a reserved name
- E32: X is not allowed as a reserved name here

- E33: length of interpreted minimum literal must not exceed reference LITLEN (X)
- E34: length of tokenized attribute value must not exceed LITLEN less NORMSEP (X)
- E35: length of system identifier must not exceed LITLEN (X)
- E36: length of interpreted parameter literal must not exceed LITLEN (X)
- E37: length of interpreted parameter literal in data tag pattern must not exceed DTEMPLEN (X)
- E38: literal is missing closing delimiter
- E39: X invalid: only Y and parameter separators are allowed
- E40: X invalid: only Y and token separators are allowed
- E41: X invalid: only Y and token separators are allowed
- E42: unknown declaration type X
- E43: X declaration not allowed in DTD subset
- E44: character X not allowed in declaration subset
- E45: end of document in DTD subset
- E46: character X not allowed in prolog
- E47: end of document in prolog
- E48: X declaration not allowed in prolog
- E49: X used both a rank stem and generic identifier
- E50: omitted tag minimization parameter can be omitted only if OMITTAG NO is specified
- E51: element type X already defined

- E52: entity reference with no applicable DTD
- E53: invalid comment declaration: found X outside comment but inside comment declaration
- E54: comment declaration started here
- E55: X declaration not allowed in instance
- E56: non-SGML character not allowed in content
- E57: no current rank for rank stem X
- E58: duplicate attribute definition list for notation X
- E59: duplicate attribute definition list for element X
- E60: entity end not allowed in end tag
- E61: character X not allowed in end tag
- E62: X invalid: only S separators and TAGC allowed here
- E63: character data is not allowed here
- E64: document type does not allow element X here
- E65: document type does not allow element X here; missing one of Y start-tag
- E66: document type does not allow element X here; assuming missing Y start-tag
- E67: no start tag specified for implied empty element X
- E68: end tag for X omitted, but its declaration does not permit this
- E69: start tag was here
- E70: end tag for X omitted, but OMITTAG NO was specified
- E71: start tag was here
- E72: start tag omitted for element X with declared content
- E73: end tag for X which is not finished

- E74: start tag for X omitted, but its declaration does not permit this
- E75: number of open elements exceeds TAGLVL (X)
- E76: element X undefined
- E77: empty end tag but no open elements
- E78: X not finished but containing element ended
- E79: end tag for element X which is not open
- E80: internal parameter entity X cannot be CDATA or SDATA
- E81: character X not allowed in attribute specification list
- E82: an attribute value must be a literal unless it contains only name characters
- E83: entity end not allowed in attribute specification list except in attribute value literal
- E84: external parameter entity X cannot be CDATA, SDATA, NDATA or SUBDOC
- E85: duplicate declaration of entity X
- E86: duplicate declaration of parameter entity X
- E87: a reference to a PI entity is allowed only in a context where a processing instruction could occur
- E88: a reference to a CDATA or SDATA entity is allowed only in a context where a data character could occur
- E89: a reference to a subdocument entity or external data entity is allowed only in a context where a data character could occur
- E90: a reference to a subdocument entity or external data entity is not allowed in replaceable character data

- E91: the number of open entities cannot exceed ENTLVL (X)
- E92: a reference to a PI entity is not allowed in replaceable character data
- E93: entity X is already open
- E94: short reference map X not defined
- E95: short reference map in DTD must specify associated element type
- E96: short reference map in document instance cannot specify associated element type
- E97: short reference map X for element Y not defined in DTD
- E98: X is not a short reference delimiter
- E99: short reference delimiter X already mapped in this declaration
- E100: no document element
- E102: entity end not allowed in processing instruction
- E103: length of processing instruction must not exceed PILEN (X)
- E104: missing PIC delimiter
- E105: an attribute specification must start with a name or name token
- E106: X is not a member of a group specified for any attribute
- E107: the name and VI delimiter can be omitted from an attribute specification only if SHORTTAG YES is specified
- E108: there is no attribute X
- E109: an attribute value specification must start with a literal or a name character
- E110: length of name token must not exceed NAMELEN (X)
- E111: an attribute value literal can occur in an attribute specification list only after a VI delimiter

- E112: duplicate specification of attribute X
- E113: duplicate definition of attribute X
- E114: data attribute specification must be omitted if attribute specification list is empty
- E115: marked section end not in marked section declaration
- E116: number of open marked sections must not exceed TAGLVL (X)
- E117: missing marked section end
- E118: marked section started here
- E119: entity end in character data, replaceable character data or ignored marked section
- E120: normalized length of attribute value literal must not exceed LITLEN (X); length was Y
- E121: syntax of attribute value does not conform to declared value
- E122: character X is not allowed in the value of attribute Y
- E123: value of attribute X must be a single token
- E124: value of attribute Y invalid: X cannot start a number token
- E125: value of attribute Y invalid: X cannot start a name
- E126: non-impliable attribute X not specified but OMITTAG NO and SHORTTAG NO
- E127: required attribute X not specified
- E128: first occurrence of CURRENT attribute X not specified
- E129: X is not a notation name
- E130: X is not a general entity name

- E131: value of attribute Y cannot be X; must be one of Z
- E132: X is not a data or subdocument entity
- E133: content model is ambiguous: when no tokens have been matched, both the Y and Z occurrences of X are possible
- E134: content model is ambiguous: when the current token is the Y occurrence of X, both the a and b occurrences of Z are possible
- E135: content model is ambiguous: when the current token is the Y occurrence of X and the innermost containing AND group has been matched, both the a and b occurrences of Z are possible
- E136: content model is ambiguous: when the current token is the Y occurrence of X and the innermost Z containing AND groups have been matched, both the b and c occurrences of a are possible
- E137: invalid comment declaration: found character X outside comment but inside comment declaration
- E138: comment declaration started here
- E139: non SGML character number X
- E140: data or replaceable character data in declaration subset
- E141: ID X already defined
- E142: ID X first defined here
- E143: value of fixed attribute X not equal to default
- E144: character X is not significant in the reference concrete syntax and so cannot occur in a comment in the SGML declaration

- E145: minimum data of first minimum literal in SGML declaration must be ""ISO 8879:1986"" or ""ISO 8879:1986 (ENR)"" or ""ISO 8879:1986 (WWW)"" not X
- E146: parameter before LCNMSTRT must be NAMING not X
- E147: unexpected entity end in SGML declaration: only X, S separators and comments allowed
- E148: X invalid: only Y and parameter separators allowed
- E149: magnitude of X too big
- E150: character X is not significant in the reference concrete syntax and so cannot occur in a literal in the SGML declaration except as the replacement of a character reference
- E151: X is not a valid syntax reference character number
- E152: a parameter entity reference cannot occur in an SGML declaration
- E153: X invalid: only Y and parameter separators are allowed
- E154: cannot continue because of previous errors
- E155: SGML declaration cannot be parsed because the character set does not contain characters having the following numbers in ISO 646: X
- E156: the specified character set is invalid because it does not contain the minimum data characters having the following numbers in ISO 646: X
- E157: character numbers declared more than once: X
- E158: character numbers should have been declared UNUSED: X
- E159: character numbers missing in base set: X
- E160: characters in the document character set with numbers exceeding X not supported

- E161: invalid formal public identifier X: missing //
- E162: invalid formal public identifier X: no SPACE after public text class
- E163: invalid formal public identifier X: invalid public text class
- E164: invalid formal public identifier X: public text language must be a name containing only upper case letters
- E165: invalid formal public identifer X: public text display version not permitted with this text class
- E166: invalid formal public identifier X: extra field
- E167: public text class of public identifier in notation identifier must be NOTATION
- E168: base character set X is unknown
- E169: delimiter set is ambiguous: X and Y can be recognized in the same mode
- E170: characters with the following numbers in the syntax reference character set are significant in the concrete syntax but are not in the document character set: X
- E171: there is no unique character in the document character set corresponding to character number X in the syntax reference character set
- E172: there is no unique character in the internal character set corresponding to character number X in the syntax reference character set
- E173: the character with number X in ISO 646 is significant but has no representation in the syntax reference character set
- E174: capacity set X is unknown
- E175: capacity X already specified
- E176: value of capacity X exceeds value of TOTALCAP

- E177: syntax X is unknown
- E178: UCNMSTRT must have the same number of characters as LCNMSTRT
- E179: UCNMCHAR must have the same number of characters as LCNMCHAR
- E180: number of open subdocuments exceeds quantity specified for SUBDOC parameter in SGML declaration (X)
- E181: entity X declared SUBDOC, but SUBDOC NO specified in SGML declaration
- E182: a parameter entity referenced in a parameter separator must end in the same declaration
- E183: reference to non-existent ID X
- E184: generic identifier X used in DTD but not defined
- E185: X not finished but document ended
- E186: cannot continue with subdocument because of previous errors
- E187: no document type declaration; will parse without validation
- E188: no internal or external document type declaration subset; will parse without validation
- E189: this is not an SGML document
- E190: length of start-tag before interpretation of literals must not exceed TAGLEN (X)
- E191: a parameter entity referenced in a token separator must end in the same group
- E192: the following character numbers are shunned characters that are not significant and so should have been declared UNUSED: X

- E193: there is no unique character in the specified document character set corresponding to character number X in ISO 646
- E194: length of attribute value must not exceed LITLEN less NORMSEP (-X)
- E195: length of tokenized attribute value must not exceed LITLEN less NORMSEP (-X)
- E196: concrete syntax scope is INSTANCE but value of X quantity is less than value in reference quantity set
- E197: public text class of formal public identifier of base character set must be CHARSET
- E198: public text class of formal public identifier of capacity set must be CAPACITY
- E199: public text class of formal public identifier of concrete syntax must be SYNTAX
- E200: when there is an MSOCHAR there must also be an MSICHAR
- E201: character number X in the syntax reference character set was specified as a character to be switched but is not a markup character
- E202: character number X was specified as a character to be switched but is not in the syntax reference character set
- E203: character numbers X in the document character set have been assigned the same meaning, but this is the meaning of a significant character
- E204: character number X assigned to more than one function
- E205: X is already a function name

- E206: characters with the following numbers in ISO 646 are significant in the concrete syntax but are not in the document character set: X
- E207: general delimiter X consists solely of function characters
- E208: letters assigned to LCNMCHAR, UCNMCHAR, LCNMSTRT or UCNMSTRT: X
- E209: digits assigned to LCNMCHAR, UCNMCHAR, LCNMSTRT or UCNMSTRT: X
- E210: character number X cannot be assigned to LCNMCHAR, UCNMCHAR, LCNMSTRT or UCNMSTRT because it is RE
- E211: character number X cannot be assigned to LCNMCHAR, UCNMCHAR, LCNMSTRT or UCNMSTRT because it is RS
- E212: character number X cannot be assigned to LCNMCHAR, UCNMCHAR, LCNMSTRT or UCNMSTRT because it is SPACE
- E213: separator characters assigned to LCNMCHAR, UCNMCHAR, LCNMSTRT or UCNMSTRT: X
- E214: character number X cannot be switched because it is a Digit, LC Letter or UC Letter
- E215: pointless for number of characters to be 0
- E216: X cannot be the replacement for a reference reserved name because it is another reference reserved name
- E217: X cannot be the replacement for a reference reserved name because it is the replacement of another reference reserved name
- E218: replacement for reserved name X already specified

- E219: X is not a valid name in the declared concrete syntax
- E220: X is not a valid short reference delimiter because it has more than one B sequence
- E221: X is not a valid short reference delimiter because it is adjacent to a character that can occur in a blank sequence
- E222: length of delimiter X exceeds NAMELEN (Y)
- E223: length of reserved name X exceeds NAMELEN (Y)
- E224: character numbers assigned to both LCNMCHAR or UCNMCHAR and LCNMSTRT or UCNMSTRT: X
- E225: when the concrete syntax scope is INSTANCE the syntax reference character set of the declared syntax must be the same as that of the reference concrete syntax
- E226: end-tag minimization should be O for element with declared content of EMPTY
- E227: end-tag minimization should be O for element X because it has CONREF attribute
- E228: element X has a declared content of EMPTY and a CONREF attribute
- E229: element X has a declared content of EMPTY and a NOTATION attribute
- E230: declared value of data attribute cannot be ENTITY, ENTITIES, ID, IDREF, IDREFS or NOTATION
- E231: default value of data attribute cannot be CONREF or CURRENT
- E232: number of attribute names and name tokens (X) exceeds ATTCNT (Y)

- E233: if the declared value is ID the default value must be IMPLIED or REQUIRED
- E234: the attribute definition list already declared attribute X as the ID attribute
- E235: the attribute definition list already declared attribute X as the NOTATION attribute
- E236: token X occurs more than once in attribute definition list
- E237: no attributes defined for notation X
- E238: notation X for entity Y undefined
- E239: entity X undefined in short reference map Y
- E240: notation X is undefined but had attribute definition
- E241: length of interpreted parameter literal in bracketed text plus the length of the bracketing delimiters must not exceed LITLEN (X)
- E242: length of rank stem plus length of rank suffix must not exceed NAMELEN (X)
- E243: document instance must start with document element
- E244: content model nesting level exceeds GRPLVL (X)
- E245: grand total of content tokens exceeds GRPGTCNT (X)
- E246: unclosed start-tag requires SHORTTAG YES
- E247: NET-enabling start-tag requires SHORTTAG YES
- E248: unclosed end-tag requires SHORTTAG YES
- E249: DTDs other than base allowed only if CONCUR YES or EXPLICIT YES
- E250: end of entity other than document entity after document element
- E251: X declaration illegal after document element

- E252: character reference illegal after document element
- E253: entity reference illegal after document element
- E254: marked section illegal after document element
- E255: the X occurrence of Y in the content model for Z cannot be excluded at this point because it is contextually required
- E256: the X occurrence of Y in the content model for Z cannot be excluded because it is neither inherently optional nor a member of an OR group
- E257: an attribute value specification must be an attribute value literal unless SHORTTAG YES is specified
- E258: value cannot be specified both for notation attribute and content reference attribute
- E259: notation X already defined
- E260: short reference map X already defined
- E261: first defined here
- E262: general delimiter role X already defined
- E263: number of ID references in start-tag must not exceed GRPCNT (X)
- E264: number of entity names in attribute specification list must not exceed GRPCNT (X)
- E265: normalized length of attribute specification list must not exceed ATTSPLEN (X); length was Y
- E266: short reference delimiter X already specified
- E267: single character short references were already specified for character numbers: X

- E268: default entity used in entity attribute X
- E269: reference to entity X uses default entity
- E270: entity X in short reference map Y uses default entity
- E271: no DTD X declared
- E272: LPD X has neither internal nor external subset
- E273: element types have different link attribute definitions
- E274: link set X already defined
- E275: empty result attribute specification
- E276: no source element type X
- E277: no result element type X
- E278: end of document in LPD subset
- E279: X declaration not allowed in LPD subset
- E280: ID link set declaration not allowed in simple link declaration subset
- E281: link set declaration not allowed in simple link declaration subset
- E282: attributes can only be defined for base document element (not X) in simple link declaration subset
- E283: a short reference mapping declaration is allowed only in the base DTD
- E284: a short reference use declaration is allowed only in the base DTD
- E285: default value of link attribute cannot be CURRENT or CONREF
- E286: declared value of link attribute cannot be ID, IDREF, IDREFS or NOTATION
- E287: only fixed attributes can be defined in simple LPD
- E288: only one ID link set declaration allowed in an LPD subset

- E289: no initial link set defined for LPD X
- E290: notation X not defined in source DTD
- E291: result document type in simple link specification must be implied
- E292: simple link requires SIMPLE YES
- E293: implicit link requires IMPLICIT YES
- E294: explicit link requires EXPLICIT YES
- E295: LPD not allowed before first DTD
- E296: DTD not allowed after an LPD
- E297: definition of general entity X is unstable
- E298: definition of parameter entity X is unstable
- E299: multiple link rules for ID X but not all have link attribute specifications
- E300: multiple link rules for element type X but not all have link attribute specifications
- E301: link type X does not have a link set Y
- E302: link set use declaration for simple link process
- E303: no link type X
- E304: both document type and link type X
- E305: link type X already defined
- E306: document type X already defined
- E307: link set X used in LPD but not defined
- E308: #IMPLIED already linked to result element type X
- E309: number of active simple link processes exceeds quantity specified for SIMPLE parameter in SGML declaration (X)

- E310: only one chain of explicit link processes can be active
- E311: source document type name for link type X must be base document type since EXPLICIT YES 1
- E312: only one implicit link process can be active
- E313: sorry, link type X not activated: only one implicit or explicit link process can be active (with base document type as source document type)
- E314: name missing after name group in entity reference
- E315: source document type name for link type X must be base document type since EXPLICIT NO
- E316: link process must be activated before base DTD
- E317: unexpected entity end while starting second pass
- E318: type X of element with ID Y not associated element type for applicable link rule in ID link set
- E319: DATATAG feature not implemented
- E320: generic identifier specification missing after document type specification in start-tag
- E321: generic identifier specification missing after document type specification in end-tag
- E322: a NET-enabling start-tag cannot include a document type specification
- E323: DTD did not contain element declaration for document type name
- E324: invalid default SGML declaration
- E325: reference to entity X for which no system identifier could be generated
- E326: entity was defined here

- E327: content model is mixed but does not allow #PCDATA everywhere
- E328: start or end of range must specify a single character
- E329: number of first character in range must not exceed number of second character in range
- E330: delimiter cannot be an empty string
- E331: too many characters assigned same meaning with minimum literal
- E332: earlier reference to entity X used default entity
- E333: empty start-tag
- E334: empty end-tag
- E335: unused short reference map X
- E336: unused parameter entity X
- E337: cannot generate system identifier for public text X
- E338: cannot generate system identifier for general entity X
- E339: cannot generate system identifier for parameter entity X
- E340: cannot generate system identifier for document type X
- E341: cannot generate system identifier for link type X
- E342: cannot generate system identifier for notation X
- E343: element type X both included and excluded
- E344: no document type declaration; implying X
- E345: minimum data of AFDR declaration must be ""ISO/IEC 10744:1997"" not X
- E346: AFDR declaration required before use of AFDR extensions

- E347: ENR extensions were used but minimum literal was not ""ISO 8879:1986 (ENR)"" or ""ISO 8879:1986 (WWW)""
- E348: illegal numeric character reference to non-SGML character X in literal
- E349: cannot convert character reference to number X because description Y unrecognized
- E350: cannot convert character reference to number X because character Y from baseset Z unknown
- E351: character reference to number X cannot be converted because of problem with internal character set
- E352: cannot convert character reference to number X because character not in internal character set
- E353: Web SGML adaptations were used but minimum literal was not ""ISO 8879:1986 (WWW)""
- E354: token X can be value for multiple attributes so attribute name required
- E355: length of hex number must not exceed NAMELEN (X)
- E356: X is not a valid name in the declared concrete syntax
- E357: CDATA declared content
- E358: RCDATA declared content
- E359: inclusion
- E360: exclusion
- E361: NUMBER or NUMBERS declared value
- E362: NAME or NAMES declared value
- E363: NUTOKEN or NUTOKENS declared value

- E364: CONREF attribute
- E365: CURRENT attribute
- E366: TEMP marked section
- E367: included marked section in the instance
- E368: ignored marked section in the instance
- E369: RCDATA marked section
- E370: processing instruction entity
- E371: bracketed text entity
- E372: internal CDATA entity
- E373: internal SDATA entity
- E374: external CDATA entity
- E375: external SDATA entity
- E376: attribute definition list declaration for notation
- E377: rank stem
- E378: no system id specified
- E379: comment in parameter separator
- E380: named character reference
- E381: AND group
- E382: attribute value not a literal
- E383: attribute name missing
- E384: element declaration for group of element types
- E385: attribute definition list declaration for group of element types
- E386: empty comment declaration

- E387: S separator in comment declaration
- E388: multiple comments in comment declaration
- E389: no status keyword
- E390: multiple status keywords
- E391: parameter entity reference in document instance
- E392: CURRENT attribute
- E393: element type minimization parameter
- E394: reference not terminated by REFC delimiter
- E395: #PCDATA not first in model group
- E396: #PCDATA in SEQ group
- E397: #PCDATA in nested model group
- E398: #PCDATA in model group that does not have REP occurrence indicator
- E399: name group or name token group used connector other than OR
- E400: processing instruction does not start with name
- E401: S separator in status keyword specification in document instance
- E402: reference to external data entity
- E403: reference to external entity in attribute value
- E404: character X is the first character of a delimiter but occurred as data
- E405: SGML declaration was not implied
- E406: marked section in internal DTD subset
- E407: NET-enabling start-tag not immediately followed by null end-tag
- E408: entity end in different element from entity reference
- E409: NETENABL IMMEDNET requires EMPTYNRM YES

- E410: reference to non-SGML character
- E411: declaration of default entity
- E412: reference to parameter entity in parameter separator in internal subset
- E413: reference to parameter entity in token separator in internal subset
- E414: reference to parameter entity in parameter literal in internal subset
- E415: cannot generate system identifier for SGML declaration reference
- E416: public text class of formal public identifier of SGML declaration must be SD
- E417: SGML declaration reference was used but minimum literal was not ""ISO 8879:1986 (WWW)""
- E418: member of model group containing #PCDATA has occurrence indicator
- E419: member of model group containing #PCDATA is a model group
- E420: reference to non-predefined entity
- E421: reference to external entity
- E422: declaration of default entity conflicts with IMPLYDEF ENTITY YES
- E423: parsing with respect to more than one active doctype not supported
- E424: cannot have active doctypes and link types at the same time
- E425: number of concurrent document instances exceeds quantity specified for CONCUR parameter in SGML declaration (X)
- E426: datatag group can only be specified in base document type
- E427: element not in the base document type can't have an empty start-tag
- E428: element not in base document type can't have an empty end-tag
- E429: immediately recursive element

- E430: invalid URN X: missing "":""
- E431: invalid URN X: missing ""urn:"" prefix
- E432: invalid URN X: invalid namespace identifier
- E433: invalid URN X: invalid namespace specific string
- E434: invalid URN X: extra field
- E435: prolog can't be omitted unless CONCUR NO and LINK EXPLICIT NO and either IMPLYDEF ELEMENT YES or IMPLYDEF DOCTYPE YES
- E436: can't determine name of #IMPLIED document element
- E437: can't use #IMPLICIT doctype unless CONCUR NO and LINK EXPLICIT NO
- E438: Sorry, #IMPLIED doctypes not implemented
- E439: reference to DTD data entity ignored
- E440: notation X for parameter entity Y undefined
- E441: notation X for external subset undefined
- E442: attribute X can't be redeclared
- E443: #IMPLICIT attributes have already been specified for notation X
- E444: a name group is not allowed in a parameter entity reference in a start tag
- E445: name group in a parameter entity reference in an end tag (SGML forbids them in start tags)
- E446: if the declared value is NOTATION a default value of CONREF is useless
- E447: Sorry, #ALL and #IMPLICIT content tokens not implemented

7.2 Country Data for the Alexa 100,000 list

Table 124 shows the countries of origin for the websites in the Alexa 100,000 list as well as the continent and GDP PPP per capita information and e-Readiness rating. The GDP PPP per capita for each country was taken from the International Monetary Fund's World Economic Outlook database for 2005. The e-Readiness ranking used was a 2005 ranking of 65 countries that was put out by IBM and the Economist Intelligence Unit.

Table 124: Country Data

Country	e-Readiness	Number of Websites	Continent	GDP (PPP) per Capita (USD)
UNITED STATES	8.73	45212	North America	43538
CHINA	3.85	17764	Asia	6761
JAPAN	7.42	6807	Asia	32617
UNITED KINGDOM	8.54	3536	Europe	31562
CANADA	8.03	2576	North America	35742
GERMANY	8.03	2434	Europe	31472
FRANCE	7.61	1858	Europe	30343
REPUBLIC OF KOREA	7.66	1755	Asia	23997
NETHERLANDS	8.28	1520	Europe	31643
HONG KONG	8.32	1437	Asia	33940
TAIWAN	7.13	1340	Asia	28789
SPAIN	7.08	1243	Europe	26009
Unreachable	-	987	-	-
RUSSIAN FEDERATION	3.98	785	Europe	12143
AUSTRALIA	8.22	776	Oceania	32296
TURKEY	4.58	758	Asia	8393
SWEDEN	8.64	706	Europe	30751
ISRAEL	7.45	679	Asia	23800
ITALY	6.95	648	Europe	30673
DENMARK	8.74	431	Europe	36083
BRAZIL	5.07	406	South America	9132
GREECE	6.19	325	Europe	22542
THAILAND	4.56	317	Asia	9166
SWITZERLAND	8.62	284	Europe	34498
CZECH REPUBLIC	6.09	269	Europe	20563

NORWAY	8.27	261	Europe	43481
No Country Found	-	248	-	-
BELGIUM	7.71	238	Europe	32894
POLAND	5.53	232	Europe	14137
INDIA	4.17	231	Asia	3490
AUSTRIA	8.01	230	Europe	34423
SINGAPORE	8.18	216	Asia	29591
HUNGARY	6.07	210	Europe	17733
MEXICO	5.21	180	North America	10475
ARGENTINA	5.05	175	South America	13813
FINLAND	8.32	172	Europe	32154
MALAYSIA	5.43	168	Europe	11915
LITHUANIA	5.04	157	Europe	15465
SAUDI ARABIA	4.38	134	Asia	13398
VIET NAM	3.06	124	Asia	2995
NEW ZEALAND	7.82	120	Oceania	25769
EGYPT	3.90	117	Africa	4498
IRELAND	7.98	107	Europe	42082
ROMANIA	4.19	107	Europe	8873
PORTUGAL	6.90	101	Europe	20846
UKRAINE	3.51	92	Europe	7803
BULGARIA	4.68	91	Europe	9976
CHILE	5.97	80	South America	12254
URUGUAY	-	75	South America	10103
SOUTH AFRICA	5.53	73	Africa	11385
VENEZUELA	4.53	70	South America	5877
BRITISH VIRGIN ISLANDS	-	70	North America	-
INDONESIA	3.07	65	Asia	4095
UNITED ARAB EMIRATES	-	65	Asia	23292
SLOVENIA	6.22	63	Europe	23102
SLOVAKIA	5.51	61	Europe	17266
SERBIA AND MONTENEGRO	-	56	Europe	5549
ESTONIA	6.32	54	Europe	17672
COSTA RICA	-	43	North America	10652
CROATIA	-	43	Europe	13185
PHILIPPINES	4.03	32	Asia	4968
COLOMBIA	4.18	31	South America	7620
PANAMA	-	31	North America	7623
PERU	4.07	30	South America	5876
LATVIA	5.11	28	Europe	13939
ICELAND	-	25	Europe	37913
GIBRALTAR	-	24	Europe	-
JORDAN	-	24	Asia	4854

DOMINICA	-	22	North America	6474
KUWAIT	-	22	Asia	16440
MALTA	-	22	Europe	20793
CYPRUS	-	20	Asia	21740
BELIZE	-	19	North America	7998
MACAO	-	19	Asia	-
LUXEMBOURG	-	17	Europe	70044
SYRIAN ARAB REPUBLIC	-	17	Asia	4004
BERMUDA	-	16	North America	-
ISLAMIC REPUBLIC OF IRAN	3.08	15	Asia	8520
GRENADA	-	14	North America	9172
PAKISTAN	2.93	14	Asia	2727
MOROCCO	-	12	Africa	4665
DOMINICAN REPUBLIC	-	10	North America	7413
ECUADOR	3.83	10	South America	4167
LEBANON	-	10	Asia	6426
PUERTO RICO	-	10	North America	-
QATAR	-	9	Asia	30326
NETHERLANDS ANTILLES	-	8	North America	24742
ANTIGUA AND BARBUDA	-	7	North America	11725
TUNISIA	-	7	Africa	8775
BOLIVIA	-	6	South America	3172
BOSNIA AND HERZEGOVINA	-	6	Europe	6160
BAHAMAS	-	5	North America	19993
GUATEMALA	-	4	North America	4260
MAURITIUS	-	4	Africa	13703
SRI LANKA	3.80	4	Asia	4443
YEMEN	-	4	Asia	755
ALGERIA	2.94	3	Africa	7390
BAHRAIN	-	3	Asia	20575
BARBADOS	-	3	North America	17783
BELARUS	-	3	Europe	8688
LIBYAN ARAB JAMAHIRIYA	-	3	Africa	11805
THE FORMER YUGOSLAV REPUBLIC OF MACEDONIA	-	3	Europe	8293
REPUBLIC OF MOLDOVA	-	3	Europe	2377
PARAGUAY	-	3	South America	4800
COTE DIVOIRE	-	2	Africa	1525
HONDURAS	-	2	North America	2906
MYANMAR	-	2	Asia	1460
NICARAGUA	-	2	North America	2883
SAINT KITTS AND NEVIS	-	2	North America	15897
SAMOA	-	2	Oceania	6628

SUDAN	-	2	Africa	2628
AFGHANISTAN	-	1	Asia	-
ALBANIA	-	1	Europe	5707
AMERICAN SAMOA	-	1	Oceania	-
BANGLADESH	-	1	Asia	2121
BOTSWANA	-	1	Africa	11561
BRUNEI DARUSSALAM	-	1	Asia	25243
CAMBODIA	-	1	Asia	2198
CUBA	-	1	North America	-
EL SALVADOR	-	1	North America	4700
FAROE ISLANDS	-	1	Europe	-
FIJI	-	1	Oceania	6558
GEORGIA	-	1	Asia	3277
GUINEA-BISSAU	-	1	Africa	885
HOLY SEE (VATICAN CITY STATE)	-	1	Europe	-
IRAQ	-	1	Asia	-
KAZAKHSTAN	2.97	1	Asia	9103
LIECHTENSTEIN	-	1	Europe	-
NIGERIA	3.46	1	Africa	1244
OMAN	-	1	Asia	17167
SENEGAL	-	1	Africa	2013
TRINIDAD AND TOBAGO	-	1	North America	16195
TURKS AND CAICOS ISLANDS	-	1	North America	-

7.3 Browser Support

The following sections contain tables for HTML/XHTML and CSS support in Internet Explorer 7 and Firefox 2. These tables have been created and maintained by David Hammond at http://www.webdevout.net/. The percent values in the columns below represent the percent of attributes implemented by either IE 7 or Firefox 2.

7.3.1 HTML/XHTML Support

HTML / XHTML		
Feature	**IE 7**	**Firefox 2**

HTML 4.01		
a	72%	88%
abbr	[illegible]	
acronym		
address		
area		
b		
base	83%	88%
bdo		
big		
blockquote	80%	
body		
br		
button	82%	
caption		
cite		
code		
col	68%	75%
colgroup	68%	75%
dd		
del	75%	
dfn		
div		
dl		
dt		
em		
fieldset		
form	[illegible]	
frame	85%	
frameset		

h1		
h2		
h3		
h4		
h5		
h6		
head	67%	33%
hr		
html		
i		
iframe		
img	85%	
input	85%	
ins	75%	
kbd		
label	81%	[illegible]
legend		
li		
link	75%	
map	80%	
meta		
noframes	50%	
noscript	63%	
object	70%	[illegible]
ol		
optgroup	71%	
option	78%	82%
p		
param	92%	
pre		

q	70%	
samp		
script		
select		
small		
span		
strong		
style	85%	
sub		
sup		
table		
tbody	77%	
td	62%	78%
textarea		
tfoot	77%	
th	62%	78%
thead	77%	
title		
tr	77%	
tt		
ul		
var		
Core attributes	75%	
Event attributes		
Internationalization (i18n) attributes	75%	
Cell alignment attributes	37%	68%
SGML inheritance	17%	38%
XHTML 1.0 changes		
HTML in XML		Y
Documents must be well-formed	I	Y

Media types	■	■
DTD changes	I	I
XHTML 1.1 changes		
rb	N	69%
rbc	N	69%
rp	N	69%
rt	N	46%
rtc	N	69%
ruby	N	69%

7.3.2 CSS Support

CSS 2.1		
Feature	**IE 7**	**Firefox 2**
CSS 2.1 Units		
Color	■	■
Counter	■	■
Integer	■	■
Length	■	■
Number	■	■
Percentage	■	■
String	■	■
URI	■	■
CSS 2.1 Importance		
!important	I	■
CSS 2.1 At-rules		
@charset	I	■
@import	I	■
@media	I	■

@page	■	■
CSS 2.1 Basic selectors		
*	I	■
E	I	■
E F	I	■
E > F	I	■
E + F	I	■
[attr]	■	■
[attr="value"]	I	I
[attr~="value"]	I	I
[attr|="value"]	I	I
.class	■	■
#id	■	■
CSS 2.1 Pseudo-classes		
:active	I	■
:first-child	I	I
:focus	■	■
:hover	I	■
:lang(C)	■	■
:link	I	■
:visited	I	■
CSS 2.1 Pseudo-elements		
:after	■	I
:before	■	I
:first-letter	I	I
:first-line	I	■
CSS 2.1 Basic properties		
background	58%	■
background-attachment	50%	■
background-color	62%	■

background-image	63%	
background-position	45%	
background-repeat	75%	
border	61%	
border-bottom	61%	
border-bottom-color	62%	
border-bottom-style	75%	
border-bottom-width	75%	
border-collapse	50%	
border-color	62%	
border-left	61%	
border-left-color	62%	
border-left-style	75%	
border-left-width	75%	
border-right	61%	
border-right-color	62%	
border-right-style	75%	
border-right-width	75%	
border-spacing		
border-style	75%	
border-top	61%	
border-top-color	62%	
border-top-style	75%	
border-top-width	75%	
border-width	75%	
bottom	70%	
caption-side	N	
clear	50%	
clip	N	
color	50%	

content	[illegible]	93%
counter-increment		
counter-reset		
cursor	90%	
direction	88%	
display	31%	75%
empty-cells	[illegible]	[illegible]
float	50%	80%
font	89%	
font-family	81%	
font-size	88%	
font-style	70%	
font-variant	50%	
font-weight	90%	
height	50%	
left	60%	
letter-spacing	63%	
line-height	75%	
list-style	67%	
list-style-image	63%	
list-style-position	63%	
list-style-type	56%	
margin	60%	
margin-bottom	60%	
margin-left	60%	
margin-right	60%	
margin-top	60%	
max-height	50%	
max-width	50%	
min-height	38%	

min-width	38%	
outline		
outline-color		
outline-style		
outline-width		
overflow	50%	92%
padding	63%	
padding-bottom	63%	
padding-left	63%	
padding-right	63%	
padding-top	63%	
position	50%	
quotes		
right	70%	
table-layout	63%	
text-align	75%	
text-decoration	64%	93%
text-indent	63%	
text-transform	58%	
top	70%	
unicode-bidi	70%	
vertical-align	46%	58%
visibility	70%	
white-space	29%	50%
width	50%	
word-spacing	63%	Y
z-index	63%	88%
CSS 2.1 Print properties		
orphans		
page-break-after	64%	57%

page-break-before	64%	57%
page-break-inside	■	■
widows	■	■
CSS 2.1 Conformance		
Conformance	43%	■